In focus…

Cryocoolers and heat exchangers

By Rhea Healy

Whether it’s heating media up or cooling it down, time is of the essence in the industrial gas industry. Companies and engineers need gases and liquid gases to be in the correct state, at the right time, on demand.

All cryogenic air separation plants rely on the humble heat exchanger at the heart of their operation and cryocoolers are essential pieces of apparatus in temperature-critical operations for such instances. Both are widely used throughout the industrial gas industry and emerging markets like the LNG sector and ‘greener’ applications are opening up a whole new realm of possibilities for the technologies.

This In Focus… explores the technological trends that are underpinning the development of heat exchangers and cryocoolers and highlights some of the innovative ways companies in the industry are using these crucial technologies to optimise their service offerings.

Extreme

Stirling Cryogenics is a leading specialist in standalone cryogenic cooling solutions, largely down to the success of its Stirling cryogenerator and cryogenic expertise, having launched its first standalone liquid nitrogen system into the market back in 1955. Its technology is based on the Stirling cycle, a thermodynamic closed cycle that was invented in 1816 by Robert Stirling.

The Stirling cryogenerator is the heart and key component of Stirling Cryogenics’ portfolio and is used across the world in advanced technological machinery to cool gases and liquids down to cryogenic temperatures.

It provides cooling power in the range of 50-6,000 watts at temperatures from -100°C to -225°C. The engine-like technology features a piston with a cold, copper head module on top. Displacing a helium medium as a gas then creates a pressure difference and creates cold through a thermodynamic loop. The cold is then stored in the head and is used to liquefy the gas that floats through it. Within just a five-minute start-up time, the cryogenerator can liquefy gases on demand.

CEO François Brouwers signified, “The cryogenerator is really the central point of our technology; most of our equipment is built around it. But we have also gained a lot of cryogenic expertise over the last decades and we are using that technological expertise to develop new, innovative cryogenic cooling solutions.”

“If you look at the cryogenic need in the world, the requirement for cryogenic cold and real extreme cold increases on a yearly basis,” he continued. “If you look at LNG (onshore and offshore) and biogas opportunities that are emerging in the market, but also in healthcare especially in developing countries, there is more need for cryogenic cold at a certain place, at a certain moment, at a certain time.” For example, Stirling Cryogenics delivered six modules of its Stirling-4 cryogenerator for the first LNG barge in the US last year.

So where, technologically, could Stirling Cryogenics’ flagship technology evolve from here? Whilst Brouwers said that the company’s plans were confidential, he did say that it sees possibilities in the market in terms of systems with a higher output compared with the output that its technology can provide at the moment. “That might be a combination of increasing the output of our existing technology and systems, but it will also be in combination with the development of new systems. Ultimately, our main goal is to be recognised by our customers as the cryogenic service provider in onsite cryogenic cooling solutions,” he said.

Vibrant

Another company that has ridden the LNG sector’s ramp-up is Cast Aluminium Solutions (CAS). The US-based business designs and manufactures heating devices for large-scale industrial gas processors, cryogenic gas processors and several end-user markets, as well as customer bases in the LNG sector.

Jeffery Awe, Marketing Director at CAS, confirmed that the LNG sector is currently the most ‘vibrant’ in terms of demand for the company’s technology, along with its traditional industrial gas and cryogas markets. Awe explained that CAS’s strength lies in the design features and functional benefits of its products, specifically the company’s CAST-X Heater line which can safely heat flammable media – even under extremely high pressures.

Inside each CAST-X Heater is a thick-walled, helical-coiled, seamless 316 stainless steel flow-tube (some models are equipped with two tubes), which are cast directly into the aluminum heater body. These flow-tubes keep the heated media isolated from the heating element and other components, allowing CAST-X Heaters to safely heat flammable gases and liquids. Each flow-tube is also capable of withstanding tremendous operating pressures, which is of critical importance in the LNG and cryogenic markets.

Additionally, isolating the media in stainless steel tubes is an effective contamination-prevention feature, making the CAST-X range compatible with food, medical and other sterile applications. According to Awe, few other heaters offer this combination of flammable media compatibility, high pressure capacity, and flow-path cleanliness.

“Awe confirmed that CAS has also noticed a drastic upturn in demand for heat exchanger technology in the LNG sector, highlighting, “Natural gas processors are morphing from successfully generating and capturing these materials to rolling them out to the marketplace on a massive scale. As the LNG and compressed natural gas (CNG) industries continue to expand, we’ve decided to parallel that growth trajectory in our CAST-X line. Plus, across all our key markets, we have seen strong demand for higher temperatures, with many customers seeking 500-600°C ranges.”

In response, Awe exclusively revealed to gasworld that CAS is about to launch its CAST-X HT (High Temp), which features a bronze heater body instead of aluminium and can maintain operating temperatures of up to 600°C.

“It’s an evolutionary product that takes the proven ‘isolated flow-path’ design of our existing CAST-X Heaters and gives it the opportunity to thrive in a new set of applications under hotter, more rigorous conditions. It’s all about adapting to changing conditions,” Awe explained.

Evolution

Cryoquip LLC, a Cryogenic Industries company, has also evolved its product line to cater for added market demands in this field. As one of the world’s leading designers and fabricators of cryogenic heat exchange systems, its capabilities span the entire spectrum of cryogenic equipment.

As Energy Sales Manager Chase Wendt explained, “Whether it’s a small ambient air vaporizer for a welding supply shop or the largest LNG re-gasification systems in the world, each heat exchanger is selected, engineered and manufactured to customer specifications.”

In terms of market trends, Wendt identified that the main growth driver for Cryoquip within the industrial gas industry has been the demand for greater precision manufacturing techniques that require higher purity environments. He also highlighted...
that product capacity demands are increasing, while the equipment being selected is moving towards a smaller size and meeting stricter environmental regulations.

In the energy sector, he revealed that the main driver for growth has been the push for more efficient, green fuel sources with lower emission footprints. “This is a global market – the world is turning to fuel sources such as natural gas and hydrogen to replace conventional fuels,” Wendt emphasised.

So having amassed over 50 years of engineering experience, how has Cryoquip’s product range developed to meet these major marketplace demands? Wendt said, “As the world evolves and moves away from conventional fuels towards cleaner burning alternatives, our product lines are responding. In the energy sector alone, we have transformed our products into more mobile and compact designs which are field-ready, including skidded virtual pipeline systems.”

“The heat exchanger will become increasingly subject to dynamics from the rest of the system along with more stringent environmental conditions”

“Our designs have also become more integrated,” he continued. “In our Fuel Fired (VFTU) water bath series for instance, the evolution of our combustion technology is providing much larger heat input rates within the same size package from just 10 years ago, all the while reducing emissions output.”

With the global demand intensifying for lower emissions and higher efficiencies, Cryoquip believes future opportunities for heat exchanger equipment lie within the ‘green’ future. “The target is the lowest emissions possible, which is driving further growth in the development of LNG systems and hydrogen fuel cells, for example,” Wendt emphasised.

“The technological future of the heat exchanger lies with properly identifying the complete environmental and operating envelope of the system it will be a part of.”

“The heat exchanger will become increasingly more subject to dynamics from the rest of the system along with more stringent environmental conditions,” he concluded.

Innovation

Whilst Cold Jet might not be a company name that you would traditionally associate with the subject matter of this feature, the dry ice innovator has been using heat exchangers to enhance the attractiveness and economic viability of its product portfolio.

Over the past five years, Cold Jet has been using a specially designed heat exchanger in its dry ice manufacturing equipment to utilise the traditional wasted cooling energy from the snow conversion process. During a standard dry ice manufacturing process and at normal commercial carbon dioxide (CO₂) supply pressure, around 40% of the liquid CO₂ is turned into solid dry ice and the other 60% is vented as gas during the manufacturing process.

By utilising the vented CO₂ gas stream in exchange with the liquid CO₂ - and by controlling the heat exchange process - Cold Jet’s equipment produces an improved liquid CO₂ yield when compared with the traditional dry ice manufacturing process.

As a result, Cold Jet has reduced the amount of liquid CO₂ needed to produce one unit of dry ice by approximately 10% – a simple calculation that translates into interesting cost savings in the long run for dry ice producers.

Arvid Nielsen, Head of Global Technology and Engineering at Cold Jet, underlined, “We have succeeded in scaling and controlling the process in a standard operating dry ice pelletizer or slice/block maker starting at capacities from 120kg per hour up to 1,000kgs per hour.”

Nielsen also believes that heat exchanger technology will become an integrated standard in dry ice machinery in the future – yet another application in which these technologies are proving to be ‘essential’ tools for optimising overall yield and efficiency.