The Advantages of Using Ambient Air Vaporizers Throughout the Entire LNG Market

Introduction

Is it possible to accomplish the regasification of LNG using no fuel, no power and no moving parts? What would be the implications of doing so? What are the benefits to the environment? Regasification of LNG is something that is rarely understood completely and seems to be shrouded in mystery in the minds of some. LNG vaporizers are quite commonplace, just follow any liquid supply chain, from a 10,000 gallon ISO container to a 70 million gallon LNG carrier, at the end of the chain you will find vaporizers that can take a variety of forms.

It takes energy to achieve regasification, and where that energy comes from is the key distinction between the various types of vaporizers. Energy comes in all forms, but some of the more popular sources for regasification include ambient air, seawater, cooling tower water, steam, electricity or even combustion of the natural gas itself. Significant interest has been devoted to using ambient air as an energy source due to its infinite free supply, zero environmental impact and lack of operational complexity. It is this technology that Cryoquip has specialized in for decades, and is the highlight of this article as we explore some of the industry background, operational explanation and modern day examples of ambient vaporizer installations.

What makes the regasification of LNG such a topic of interest in recent years, and why has it become such a complicated issue? In a changing world, public awareness of heretofore uninteresting chemical and hydrocarbon-based processes has become a significant item of focus. What was once a relatively mundane topic, has become sensationalized. One need not look very far to find news reports and documentary presentations discussing the potential issues surrounding LNG as a supplement for the world's energy demand.

LNG represents the world's largest cryogenic regasification energy demand simply because the majority of suppliers and end-users are separated by oceans and continents. Therefore regasification is no small matter and there are many considerations when evaluating the various technologies associated with LNG vaporizers. No longer is the methodology for regasifying LNG relegated to a few agencies authorized to approve the process. The general public is now intimately involved which brings a number of beliefs and attitudes to this process ranging from "not in my back yard" to "is it safe for my family and neighborhood" to "what are the associated carbon emissions".

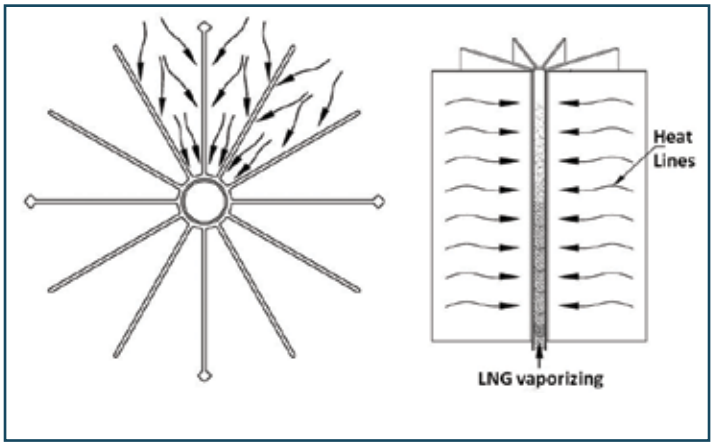

Figure 1. Sample illustration of the heat transfer mechanism using a 12-fin extrusion.

No reasonable person would argue that a 1970's vintage vehicle could be the answer to the perennial 'fuel crises' that seem to recur with each new generation. Similarly, the conventional methods for regasification of LNG have been pressured to improve, and newer methods are receiving serious consideration. Some of the strongest influences pressuring the adoption of alternative regasification methods include concerns over CO2, SOx, NOx and CO emissions. Also, the unknowns associated with using large quantities of seawater for regasification, have increased the rejection of or objection to the old 'tried and true' technologies. Because of these and other legitimate concerns, numerous 'hurdles' have been added to the success equation for regasification of LNG. Since the original LNG advancement efforts 40 years ago, concerns about pollutant emissions, climate change and environmental impact have become considerably more politicized issues.

Background

With regard to the current public and political awareness of LNG, it is from this context that we approach the topic of the simplest form of regasifying cryogens, that is direct contact ambient air vaporizers known in the industry as AAV's and forced draft fan ambient vaporizers, or FAV's. One of the many questions asked about ambient vaporizers is "why have they not been used for regasifying LNG for 40 years like some of the other alternatives?" Although ambient vaporizers have been used to regasify cryogens, including LNG, for more than 50 years, they were not available until recently, in a configuration suitable for the high flow rates associated with modern day LNG user applications. More than 50 years ago, industrial gas suppliers working with Cryoquip, determined ambient vaporizers were the simplest, safest, cleanest and most reliable device for regasification of cryogens from CO2 through argon, oxygen, nitrogen, hydrogen, helium and a variety of other cryogens.

The air separation companies have made a significant effort over the years to maximize the size and application of ambient vaporizers around the world. It is conservatively estimated that more than 50,000 such units are employed currently around the world in a multitude of applications.

As the air separation industry designed and built ever larger plants and this progression resulted in and the demand for much larger capacity ambient vaporizers. Today, it is commonplace for Cryoquip to supply the industrial gas companies with hundreds of ambient vaporizers each year for deployment all around the globe. These ambient vaporizers can accommodate flow rates 10 – 20 times higher than their predecessors 20 years ago. The ambient air technology has come a long way since its infancy half a century ago.

continued

Figure 2. Send-out ambient vaporizer train at Cheniere's Sabine Pass LNG terminal.

Technical Discussion

What makes an ambient vaporizer greener than other regasification processes? First, it uses a completely renewable energy source, which is heat generated by the sun every day and carried in the ambient air we all breathe. There are no fuel or power requirements with ambient vaporizers, which makes it a truly unique technology. In addition, the only environmental impact created by operating ambient vaporizers is the removal of moisture from the ambient air. As the air reduces in temperature to heat the cryogen inside the heat exchanger, moisture is deposited onto the external surfaces.

One of the most significant beneficial characteristics of this direct contact ambient system is that it relies upon a single approach temperature. This is not always the case with some indirect ambient systems where multiple approach temperatures are required. In general, more intermediate degrees of separation between the air and LNG result in decreased thermal efficiency and more operational complexity.

The pressurized LNG is passed on the tube side through the internal section of the finned heat exchange element, known in the industry as extrusions. Nature, not liking a thermal imbalance, immediately begins to warm the very cold fluid. Enhancing this process, the stainless steel tube carrying the LNG is metallically bonded to a set of aluminum fins directed radially outward. This allows heat to pass more easily between the ambient air and the LNG being heated. Proper design of the internal section assists in maximizing heat transfer to the LNG being heated. These finned sections are connected together to create large arrays and are firmly held in place in a honeycomb type attachment. This arrangement allows for easy scaling of additional extrusions for a wide range of LNG flow rates. Also, there are a large number of possible tube side configurations, allowing flexibility in the number of parallel and series passes.

Part of the popularity of ambient vaporizers is due to the simplicity of the process. The natural thermodynamic progression is that surrounding ambient air begins to cool while giving up its sensible heat to the LNG. As this occurs, the air becomes denser and begins to fall under gravity's control. As the ambient air continues to chill, the velocity increases as does the external heat transfer coefficient. In essence, the reverse effect of a chimney is being created. When air is heated in a fireplace or other device, the heated air becomes lighter and rises. This effect can be rather dramatic, especially as the height of a chimney increases, increasing the draft, hence the very large slender stacks seen at power plants and smelters. Exactly the opposite effect occurs when cooling air with LNG. In addition, a fan can be mounted on the top of an ambient vaporizer to offer further performance enhancement. Something to keep in mind, is that there is no climate on Earth that is too cold to vaporize LNG, therefore, direct contact ambient vaporizers will always be capable of regasification no matter where they are installed.

As the air cools, it reaches the saturation point and the moisture within the air begins to condense. This creates a significant benefit because the heat of vaporization of the water is relatively high. As the moist air continues to cool, the temperature drops to the point where ice as crystalline frost begins to form on the external surfaces of the extrusion. This supplies additional energy from the heat of fusion. Because of this freezing process, design consideration needs to be given to the accumulation of this frost which attaches to the extrusions. Frost formation has led Cryoquip to develop extrusions which can accommodate various amounts of frost with significant heat transfer performance still being achieved. Each type of fin and spacing has a characteristic performance curve in ambient air. Years of research and testing have resulted

Figure 3. Cryoquip ambient vaporizer installation at Shenzhen Gas' LNG peak shaving plant.

in a design program that predicts the performance of the various sizes, types and configurations of extrusions for a wide range of cryogens.

After a reasonable period of time, usually several hours, the frost builds to the point where it begins to reduce the heat transfer below a predetermined level. At this point, the unit is taken out of service and allowed to defrost, while another ambient vaporizer is activated. The ces are so efficient, this happens quickly in comparison to the online time, and vaporizers can be quickly returned to service.

Applications

In the ever expanding LNG market, applications for ambient vaporizers are always growing. As previously mentioned, any liquid supply chain that you follow will terminate in a vaporizer in one form or another. Ambient vaporizers are very flexible by nature due to their modular construction making them fit for any flow rate or pressure. In addition, extrusions can be manufactured in lengths up to 40ft. which means relatively large equipment can be shipped in 45ft containers for transport cost savings. Cryoquip has manufactured the largest ambient vaporizers ever produced, which are installed for send-out regasification purposes at Cheniere's Sabine Pass LNG terminal. Given the immense scale of this terminal, correspondingly the vaporizers are 12ft (L) x 12ft (W) x 50ft (H) and were transported as special permitted loads from California to Louisiana. Furthermore, ambient vaporizers are used on the export liquefaction side of the Sabine Pass terminal for flaring purposes. When the liquefaction train runs into an 'upset' condition, the off-product from the cold boxes is vaporized and sent to the flare.

In addition to the large regasification terminals, ambient vaporizers are also used in many peak shaving facilities, most notably in China.

Ambient vaporizers lack any moving parts and their energy source is always available, even on the coldest day of winter. This makes ambient vaporizers very reliable and an excellent choice in critical performance situations where a gas supply outage is highly troublesome.

Moving further down the size scale, ambient vaporizers can also be used for industrial heat and power generation, otherwise known as virtual pipeline or satellite LNG installations. These typically are retrofit conversions of boilers, burners, kilns and generators from diesel or LPG to natural gas. Cryoquip recently completed a number of these types of projects in the Northeastern U.S., the Caribbean and Australia using ambient vaporizers with great success which produced significant daily fuel expense savings for the industrial users. In the very near future, the LNG conversion wave will reach islands around the world, where power costs are extraordinarily high compared to the mainland.

Ambient vaporizers are routinely installed at LNG fueling stations for trucks and vehicles. In particular they are used as LNG warmers for saturating the fuel before dispensing in 'warm' fuel stations. In addition, they are combined with a high pressure pump for the production of CNG from LNG when the fueling station lacks a compressor.

Not surprisingly ambient vaporizers have found their way into nearly every corner of the LNG market, as many LNG users have discovered the same advantages that the industrial gas companies recognized many decades ago.

For further information, visit to www.cryoquip.com.

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Figure 4. Satellite LNG ambientvaporizer system for industrial heat and power in the Northeastern U.S.