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Discussion on cold energy utilization technology of LNG receiving station

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Abstract

Liquefied Natural Gas (Liquefied Natural Gas, abbreviated as LNG) has an expanding market due to its good cleanliness and economy. When LNG is used, it needs to be regasified. One ton of LNG gasification can release about 240kWh of cold energy. Recycling the cold energy released in the process of LNG gasification can not only save energy, reduce the cost of natural gas, but also reduce the environmental pollution caused by LNG gasification, which has considerable economic and social benefits. At present, the cold energy utilization technology of LNG has been paid more and more attention and become one of the hot spots in the research of LNG technology.

Keywords

LNG; Cold energy utilization; Treatment process.

1. Introduction

China is a big energy consumer, coal accounts for 60% of the total energy consumption, resulting in serious air pollution, and to solve this problem, it is urgent to change the structure of the energy industry, and LNG plays a significant role in optimizing the current energy structure. In recent years, Liquefied Natural Gas (LNG) has been expanding its market due to its good cleanliness and economy. Bp forecasts that the world LNG trade will continue to grow at an annual rate of 4.4% over the next 30 years. According to statistics, China imported 5.53 million tons of LNG in 2009, 9.47 million tons in 2010 and 14.8 million tons in 2012, showing a multiple growth. According to China's current LNG use plan, it is estimated that China's demand for LNG will reach 400 billion cubic meters by 2025, which means that there will be a gap of 250 billion cubic meters, which needs to be made up by importing LNG[1]. At present, LNG has been widely used in residential gas, industrial gas, power generation, LNG vehicles and other fields. It can replace coal, liquefied petroleum gas (LPG) and other fuels to a large extent, and has strategic significance to change China's energy structure. Besides, the coastal LNG receiving station has diversified resources and adjustable scale, which can play a peak-regulating role for onshore natural gas and ensure safe and stable gas supply.

From the current LNG production process, liquefied one ton of natural gas consumes about 850kWh of energy. Natural gas is mostly utilized in gaseous form, so LNG needs regasification when it is used. About 240kWh of cold energy can be released when one ton of LNG is vaporized[2]. Therefore, while importing LNG, a large amount of cold energy is also imported. If a terminal imports 5 million tons of LNG per year, it can get 1.2 billion KW of cold energy. If this part of cold energy is not recycled, it will cause a great waste of energy. At present, the receiving stations mostly use open-frame sea water vaporizers and submerged combustion vaporizers. The former uses seawater as the heat source and has low operating cost, but a large amount of cold energy enters the sea near the receiving station with seawater, which lowers the sea temperature and causes cold pollution to the ecological environment of the nearby sea. The latter uses hot water as the heat source for GASIFICATION of LNG, and indirectly heats hot

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water by burning natural gas, thus consuming 1.3% of LNG. In addition, nitrogen oxide, carbon dioxide and other greenhouse gases are produced in the combustion process, which has certain impact on the environment. Therefore, recycling the cold energy released in the process of LNG gasification can not only save energy, reduce the cost of natural gas, but also reduce the environmental pollution caused by LNG gasification, which has considerable economic and social benefits. At present, the cold energy utilization technology of LNG has been paid more and more attention and become one of the hot spots in the research of LNG technology.

2. Basic properties of LNG

(1) Heat transfer of LNG. In the process of the transportation of natural gas, for the convenience of storage, need through technical processing, the state of the gas into liquefied natural gas, natural gas will be an increased density of liquefied natural gas (LNG), usually up to standard conditions of methane density of more than 600 times, is about 7/10 of the low energy density of gasoline system, due to environmental factors and the limitation of the technical level, The boiling point of LNG is usually between -157℃ and -163℃, while the boiling point of pure methane is between -161℃. The density of LNG is between 0.47 and 0.53, and that of pure methane is 0.45. Similarly, The freezing point, calorific value and dry air concentration of LNG and pure methane are different. If LNG is considered as lean gas, methane accounts for up to 96% of its volume fraction. Based on this, the correlation between the thermal conductivity of LNG and temperature, specific heat and temperature, and viscosity and temperature can be calculated. The thermal conductivity, viscosity and temperature are negatively correlated. The higher the temperature is, the lower the thermal conductivity is; similarly, the higher the viscosity is, the lower the thermal conductivity is, while the specific heat capacity of LNG is positively correlated with temperature[3].

(2) Cold exergic characteristics of LNG. In this process, the maximum useful energy of LNG can be obtained through calculation of the system stable flow energy equation. Assuming that the external temperature is constant at 25℃, at the state of 1.6Mpa, it is necessary to generate cold energy for 1 t liquefied natural gas to rise from -160℃ to 25℃. When the temperature is less than -110℃, the cold energy produced by LNG is linearly correlated with the temperature. When the temperature exceeds -110℃, the state of LNG will change, and the release of cold energy will show a linear change. From this change, it can be seen that the pressure of LNG is negatively correlated with the cold energy [4]. This is mainly because when LNG is pressurized by atmospheric pump, part of LNG is transformed into exergy of pressure. The higher the pressure is, the more exergy of cold exergy will be transformed and the corresponding cold exergy will be reduced.

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Methods of cold energy recovery and utilization of LNG

Through the study of LNG, it is found that the cold energy generated in vaporization is very widely used, and different recovery approaches can be adopted according to the difference of production pressure and low temperature. It mainly includes power generation, air separation freezing, refrigeration, dry ice manufacturing, etc. Considering the low temperature cold energy temperature is lower, its refrigeration performance is stronger, so as far as possible in the low temperature environment using cold energy. LNG cold energy utilization can be divided into direct utilization and indirect utilization.

3. Direct utilization

3.1. Cold storage and freezing system

The application of LNG cold energy in refrigeration system can reduce the operating pressure and loss of refrigeration system, reduce the investment and operation cost of cold storage, and save a lot of refrigeration electricity. In order to improve the utilization rate of cold energy of LNG, it can also be applied to food freezing processing and pre-cooling equipment, and combined with the temperature difference of different processes to build a cold energy process chain, so as to give full play to the cooling capacity of different temperatures in the process of cold energy reheating, so as to improve the utilization rate of cold capacity.

3.2. Make dry ice or liquid carbon dioxide

The cold energy of LNG can be used to produce liquid carbon dioxide and dry ice effectively. Since the freezing point and boiling point of carbon dioxide are both higher than the saturation temperature of LNG, the cold energy benefit can be further improved under the condition of controllable cold energy temperature. Using LNG cold energy to produce liquid carbon dioxide, can be used in casting, welding and other fields. The production of liquid carbon dioxide through LNG cold energy can greatly improve the purity and save power loss. Compared with the traditional manufacturing method, the production of liquid carbon dioxide through LNG cold energy recovery device consumes about 0.2W/m2 of electric energy, which can save 10% construction cost and 50% power consumption[6].

3.3. Air Separation

The larger the difference between ambient temperature and low temperature, the stronger the air separation performance. The air needs 650kcal cooling energy, and the application of LNG cooling capacity to the air separation device can not only reduce the construction cost, but also greatly reduce the electric energy loss per 1m3 of liquefied oxygen production, which can be reduced from the initial 1.2kwh to 0.5kwh[7]. LNG cold energy is widely used in the field of air separation because it can effectively reduce the power consumption.

3.4. Cold energy generation

LNG cold energy generation technology is relatively mature, there are three main methods: first, direct expansion method. The natural gas is compressed into LNG high-pressure liquid, and then heated to normal temperature by sea water through heat exchanger. The mechanical energy is provided by using turbine expansion to do external work. This method has a relatively simple cycle process and less equipment investment. However, the cold energy of LNG is not fully utilized, so 1t OF LNG can only generate 20kWh[8]. Second, the secondary media law. The LNG cold energy is transmitted to the refrigerant through the condenser, and the refrigerant

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steam power cycle is realized by using the temperature difference between the two to achieve work. The cold energy utilization rate of this method is higher than that of expansion method, but the condensing temperature utilization rate is low, so the overall recovery rate needs to be enhanced. Finally, the synthesis method, that is, the combination of the above two methods. Firstly, the compressor is used to increase the LNG pressure, then the condenser drives the secondary media to realize the steam power cycle, and the natural gas is expanded through the gas turbine to do work, so as to realize the complementarity of advantages and disadvantages.

4. Indirect utilization

4.1. Low temperature crushing

Because any material has broken nature, frozen crushing is stronger than room temperature crushing performance, can break the material into small particles, and can be separated, mainly using liquid nitrogen. LNG, due to its very low liquid temperature, can be used to make liquid nitrogen to achieve low temperature crushing function. This method does not exist odor pollution and particle explosion, and can selectively break complex mixtures[9]. Therefore, this technology has a very good application prospect in resource recovery, material separation, fine crushing and other fields.

4.2. Sewage treatment

LNG can be used to produce liquid oxygen to obtain high purity ozone, which can effectively absorb ozone in sewage and achieve sewage treatment. Compared with traditional ozone treatment, this method can reduce the power loss by 1/3, and the sewage treatment effect is very good.Three, LNG cold energy recovery and utilization matters needing attention

(1) Temperature requirements

In low-temperature production, it can be found that the required power changes according to the temperature change, and the relationship between the two is inversely proportional, that is, the lower the temperature, the higher the required power. In low-temperature environment, the required work increases rapidly, which reduces the operating efficiency and increases the production cost to a certain extent. Therefore, it is necessary to make full use of the low temperature of -160℃ in the LNG cold energy process, instead of blindly reducing the temperature.

(2) Dosage requirements

LNG is most widely used in power plants and gas units, and most of the production is all-day operation, which brings a huge operating load to the gas system and power generation system, and the amount of LNG used will also change[10]. In order to make full use of the cold energy of LNG, the system should be regulated. LNG supply load can be adjusted according to the load trend of gas and power generation system, so as to maximize the benefits of LNG cooling energy.

(3) Factory location

Due to the particularity of LNG, it is necessary to use a special pipeline system to transport LNG, and the pipeline material requirements are very high. In the process of transmission, there will be transmission pressure loss, heat absorption and cooling loss. Therefore, the cold energy utilization field is as close as possible to the LNG terminal receiving station. In order to purchase and sell the LNG cold energy utilization plant, it has certain requirements on the convenience of transportation, which results in the contradiction of site selection.

(4) Safety restrictions

For LNG cold energy recycling, the most ideal method is direct utilization, such as power generation, air separation, refrigeration and freezing, but LNG is flammable and explosive characteristics, so as to reduce the heat exchange between LNG and substances, let alone

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contact with open fire. In practical application, there are not a few accidents in which air and leaked natural gas mix to form explosive gas. Therefore, it is necessary to focus on the safety of LNG cold energy utilization and ensure the tightness of transmission system and production system. The use of refrigerant will make the system more complex and cost more.

(5) Indirect utilization restriction

Using LNG to produce liquefied oxygen and liquefied nitrogen consumes a large amount of LNG cold energy and electricity, and the production cost is relatively high. At the same time, although some processes can achieve the production method, the cost is still difficult to reduce to a reasonable range[11].

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