ISSN: 2664-9640

Analysis of the Utilization Method of LNG Cold Energy

Li Li, Qin Jing, Shen Lisha, Su Ruiyu

Xi'an Shiyou University, Xi'an, Shaanxi 710000, China

Abstract

LNG is a cryogenic liquid that cools gaseous natural gas to -162℃. When LNG is gasified, it will release a large amount of cold energy. The rational use of cold energy has very important economic and social value. The article mainly introduces the main methods of LNG cold energy utilization, and looks forward to the new development trend of LNG cold energy utilization in the future.

Keywords

LNG cold energy utilization cold energy utilization rate.

1. Introduction

LNG is the abbreviation of Liquefied Natural Gas. It is a cryogenic liquid that cools 101.325KPa of natural gas to -162 ℃. The volume is about 1/600 of the original volume. Its main components are methane and ethane, and it also contains a small amount of gas. Hydrocarbons such as propane and butane. In the LNG gasification station, a large amount of cold energy will be released during LNG gasification, the value of which is about 840kJ/kg[1]. Therefore, making full use of the cold energy released during LNG gasification can effectively reduce energy consumption and capital investment, and has very important economic and social value.

2. LNG cold energy utilization method

The cold energy released during LNG gasification has a wide range of uses, including cold energy power generation, air separation, production of liquid CO_2 and dry ice, seawater desalination, and cold storage.

2.1. Cold energy power generation

Since LNG has a low temperature of -162℃, the main method of cold energy power generation is to use low temperature to condense the working fluid and then pressurize it to gasify it to high pressure and high-temperature gas and then generate power in a steam turbine. Cold energy power generation is the recovery of cold energy in the form of electrical energy[2]. There are three main methods: direct expansion, low-temperature Rankine cycle, and low-temperature Brayton cycle.

(1) Direct expansion method

Direct expansion power generation means that the gasified LNG enters the steam turbine to drive power generation. LNG is heated to room temperature with seawater in the evaporator and then expanded by a turbine in the steam turbine to perform external work and generate mechanical energy. This method is simple in process and convenient to operate, but its cold energy utilization rate is low, and it cannot be applied to medium and large LNG receiving stations.

(2) Low-temperature Rankine cycle method

With steam as the circulating working medium, the Rankine cycle is an ideal cyclic process composed of isentropic compression, isobaric heating, isentropic expansion, and isobaric condensation. The low-temperature Rankine cycle method uses low-temperature LNG as a cold

ISSN: 2664-9640

source and re-condenses the working fluid in the Rankine cycle through a heat exchanger, thereby using the temperature difference between the cold source and the heat source to perform the steam power cycle to perform external work and generate energy[3]. The working fluid in the low-temperature Rankine cycle method is pressurized by the pump and the heater absorbs heat, then enters the steam turbine to expand and perform work, and then is re-liquefied by LNG to complete a complete cycle.

This method is generally combined with the direct expansion method to generate cold energy. The process is simple and the operation is convenient. It can use cold energy more efficiently and improve the utilization rate of cold energy. In addition, this method does not require a high temperature of the heat source, and there are many options for the heat source. Therefore, the combined method for cold energy generation is the first choice for most technological processes. The disadvantage of this process is that the high-grade cold energy of LNG cannot be used, resulting in the overall low utilization rate of cold energy.

(3) Low-temperature Brayton cycle method

The low-temperature Brayton cycle method is similar to the low-temperature Rankine cycle method. The low-temperature Brayton cycle method mainly uses N_2, CO_2 and other gases as the circulating working medium. The working fluid has always existed in a gaseous state during operation, resulting in a continuous decrease in the heat release curve, resulting in a higher match between the temperature of the LNG cold source and the temperature of the working fluid heat source, resulting in a good increase in heat exchange efficiency and a good utilization rate of cold energy. Has been increased[4]. However, this method has higher requirements for the temperature of the heat source used to heat the working fluid, which makes the temperature difference between the heat source and the cold source larger, the heat exchange temperature difference is larger, and the loss generated during the cycle is larger. Therefore, this method uses more few.

2.2. Air separation

Air separation refers to the process of separating its components (O, N, Ar, etc.) from the air, and its main principle is cryogenic freezing. Generally, the air is first compressed and cooled to a low temperature, or it is liquefied with an expander, and finally separated in a rectification tower. When the temperature difference between the ambient temperature and the low temperature is larger, the separation effect is more obvious. Since the temperature in the working area of the air separation equipment is between -190℃ and -150℃, the cold energy of LNG is used for air separation. Effective separation of LNG cold energy and air. The main principle is to place high-quality low-temperature cold energy in the air separation device, combine its gasification and air separation systems, and rely on the high-quality low-temperature cold energy of LNG to further reduce the actual cold energy loss in the air separation system. Optimize the transformation process, save a lot of construction costs, increase the start-up time of the air separation equipment, and improve the production efficiency of the equipment[5]. The larger the gap, the stronger the air separation performance. Air requires 650kcal cooling energy, and the application of LNG cold capacity to the air separation plant can not only reduce construction but also greatly reduce the power loss per m^3 of liquefied oxygen produced, which can be reduced from the initial 1.2kWh to 0.5kWh[6]. Because it can effectively reduce the amount of electricity used, LNG cold energy is widely used in the field of air separation.

2.3. Making liquid CO_2 and dry ice

Since the freezing point and boiling point of carbon dioxide are higher than the saturation temperature of LNG, under certain conditions, liquid carbon dioxide and dry ice can be made from LNG cold energy to improve the utilization rate of LNG cold energy. CO_2 is often used as a shielding gas in casting, welding, and other fields, and dry ice is often used in low-temperature freezing, artificial rainfall, and cooling and keeping fresh. The cold energy of LNG is used to produce liquefied carbon dioxide. The pressure during liquefaction is lower than 1MPa, which reduces the equipment load and saves 30% to 40% of the electricity consumption. The overall cost is lower and the produced carbon dioxide purity is higher[7] . Therefore, LNG cold energy is also widely used in the production of liquid CO_2 and dry ice.

2.4. Desalination

The process of obtaining fresh water from seawater is called desalination. As one of the open-source incremental technologies to realize the utilization of water resources, seawater desalination can increase the total amount of fresh water and ensure a stable water supply. Seawater desalination is achieved by applying LNG cold energy, which mainly uses the freezing method[8], that is, in the actual freezing process of seawater, the phenomenon of "saltwater separation" will occur. The actual salt content in the ice body is lower at a lower temperature, and the actual salt content is lower. Effectively realize the separation of saltwater and ice, and the final product is freshwater. This technology mainly uses LNG cold energy as a cold source for seawater desalination and reduces the cost of the process flow. Therefore, LNG cold energy is widely used in the field of seawater desalination.

2.5. Cold storage

As a kind of refrigeration equipment, the cold storage is usually located near the transportation port or the place of origin. Cold storage refers to the use of artificial means to create an environment different from outdoor temperature or humidity. It is also used for food, liquids, chemicals, medicine, vaccines, scientific experiments and other items. Constant temperature and humidity storage equipment. When LNG cold energy is used to cool the cold storage, the operating pressure and loss of the refrigeration system can be reduced, the investment and operating costs of the cold storage will be reduced, and a large amount of cooling power will be saved.

3. Conclusions and prospects

my country is a big energy-consuming country, coal accounts for 60% of total energy consumption, which has caused serious air pollution. To solve this problem, it is urgent to transform the structure of the energy industry, and LNG plays a major role in optimizing the current energy structure[9].LNG has become a new direction of energy development under its cleanliness and economy. The implementation of LNG cold energy utilization can not only improve the energy utilization level but also bring huge economic benefits.

Therefore, two prospects are put forward for the development prospects of LNG cold energy utilization in the future:

1. The surrounding environment of the LNG receiving station has a greater impact on the LNG cold energy utilization project. Therefore, the preliminary planning of the receiving station should be carried out based on fully considering the utilization of LNG cold energy and adopting measures to local conditions to maximize the production needs.

2. The utilization of cold energy will be cascaded utilization of cold energy that tends to be at different temperatures, reducing cold energy exergy and improving cold energy utilization[10].

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ISSN: 2664-9640

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About the author: Li Li (1996-), female (Han nationality), from Baiyin, Gansu, master student at Xi'an Shiyou University, studying at Lanzhou City College from 2016 to 2020, mainly engaged in the research of LNG cold energy utilization, Tel: 18894024135, E-mail :319244693@qq.com.