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Regasication of the cryogenic working substance in tanks using cryogenic generators due to its use of cold energy

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Abstract

This article describes an issue hraneiya cryogenic products in tanks. On the basis of reference data to determine the total and specific daily losses of cryogenic low-grade heat, depending on the volume of the reservoir, as well as complete and specific daily losses of available energy when used for its low-grade heat cycle Karno.Predlozheny three circuits of low-temperature power plant, allowing to make reozhizhenie evaporating of cryogenic and return it to the storage tank to obtain additional electrical energy.

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Keywords: Cold energy; liquefied natural gas; steam power plant; cryogen.

1. Introduction

Many systems of aerospace technology and transport and also systems of the energy different purposes energy complex now are widely using cryogenic liquids.

For accumulation, storage and dispensing of cryogenic liquid as part of the energy systems cryogenic tanks are used. This are spherical and cylindrical tanks (vertical or horizontal) with volume up to 250 m^3 and spherical tanks with volume up to 1440 m^3.[1]

Shape of tanks is chosen in accordance with their purpose, convenience of manufacturing, transportation and operation. A tendency to reduce the heat gains to the stored liquid has an additional influence on the shape of the

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tanks. From the point of view of ensuring the minimal heat leakage the spherical shape of the tanks is more preferable, because the ratio of surface to volume for the sphere is minimal in comparison with other geometric shapes. However, the working area and volume is underutilized at the spherical shape of the vessels. In connection with this, in addition to spherically shaped vessels the vertical and horizontal cylindrical containers are widely used, whose shape much better takes into account vehicle overall dimensions, allows to use more rationally the working areas, makes it possible to produce a number of single-type tanks of different volumes by changing the length of the shell.

During storage of cryogen the losses of cryogen arise due to imperfection in insulation and heat gains from the environment. During storage of cryogenic substance because of mass losses its enthalpy changes. It is possible to carry out the losses calculation of cold energy of cryogen per day, which is lost during its storage, by the following relations:

$$\Delta m = m_{\Sigma} \cdot \frac{\Theta}{100} \tag{1}$$

$$Q_{ev} = \Delta m \cdot r + c_p \cdot \Delta m \cdot (T_c - T_e) \tag{2}$$

where Δm - the mass of evaporated cryogen per day, m_{Σ} - the mass of stored cryogen; Θ - evaporation losses of product per day, % Q_{ev} - cold energy of evaporated cryogen; r - heat of cryogen evaporation of; T_c – cryogen temperature; T_e – environmental temperature.

Evaporable cryogen has a sufficiently high specific potential of cold energy [2][3][4], which can be used as a "refrigerator" in the heat engine operating by the Carnot cycle. The loss of available energy L_{out} per day if cold energy of cryogen used by Carnot cycle (Figure 1) calculates as follows:

$$L_{out} = \frac{Q_{ev} \cdot \eta}{1 - \eta} \tag{3}$$

$$\eta = 1 - \frac{T_c}{T_e} \tag{4}$$

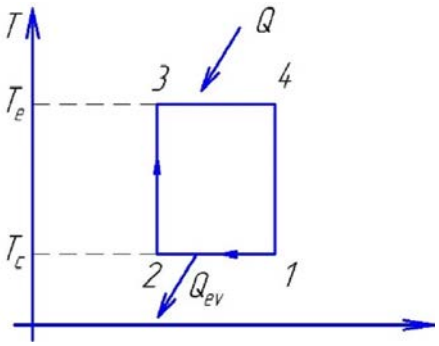

Fig. 1 The thermodynamic cycle of the heat engine working by Carnot cycle

2. Characteristics of different types of tanks

The analysis of the main technical characteristics is performed. Also it was carried out calculations of energy losses in the cryogenic storage systems for horizontal and vertical cylindrical tanks with screen-vacuum insulation for different cryogenic substances, which is commercially available. Table 1 shows data for reservoirs with cryogen storage pressure of 0.6 MPa, and Table 2 shows data for reservoirs with cryogen storage pressure of 1.7 MPa.

Considering the data presented in Tables 1 and 2, dependencies of weight-size and power characteristics of cryogenic tanks and systems according to their volume and storage pressure were constructed.

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