УДК 621. 51

ENERGY-SAVING HEAT EXCHANGERS FOR SHIPBOARD MICROCLIMATE AND REFRIGERATION SYSTEMS

Olena V. Lytosh
Ph. D., associate professor
Admiral Makarov National University of Shipbuilding,
Mykolaiv, Ukraine
olena.lytosh@nuos.edu.ua

Abstract. A necessary condition for increasing competitiveness and meeting the requirements of the world ship market is rational consumption of fuel and energy resources by the ship, first of all those related to cold consumption. The purpose of research esisanestimation of efficiency of applicationin shipboard microclimate and refrigeration systems of tube-and-plate heat exchangers with the increased rib pitch. As a result of the research, it was found that, the use of heat exchangers having a unified tube-and-plate surface with a fin spacing of 4...6 mm allows reducing fuel consumption by shipboard microclimate and refrigeration systems by about 12 %.

Keywords: energy saving, shipboard microclimate and refrigeration systems, tube-and-plate heat exchangers, rib pitch.

Introduction. A necessary condition for increasing competitiveness and meeting the requirements of the world ship market is rational consumption of fuel and energy resources by the ship, first of all those related to cold consumption. The presence of significant reserves in this direction is evidenced by the results of the author' analysis of fuel consumption items by ship, which show that the share of fuel consumption for production of electric power consumed by microclimate and refrigeration systems (MRS) for passenger ships and fishing fleet ships is comparable with its costs for ensuring the ship's running and makes up 20...30 % of fuel consumption for the ship as a whole [1].

Increased temperature differences in heat exchangers (HE) MRS – air coolers (AC) and air-cooled condensers (ACC) – testify to significant reserves for reduction of power consumption by MRS due to reduction of thermal and aerodynamic resistances of HE.

For HE of air conditioning systems (ACS), tube-and-plate surfaces with fin spacing S_P = 2,2and 2,8mm are used, which corresponds to fin spacing coefficients β' about 13 [2]. However, a surface with such fin spacing cannot be used for the AC of refrigeration systems (RS) due to frost landing on the plate fins and tubes and unacceptable increase in the aerodynamic resistance of the AC. To avoid this, surfaces with increased fin spacing S_P = 4…6 mm are used in RS [3].

A similar picture is observed for ACC placed on the deck of ships. Salt contained in humid sea air settles in the intercostal channels and tubes of ACC and reduces the passage cross-section with the consequent consequences.

Aim. The purpose of research esisanestimation of efficiency of applicationin shipboard MRS of tube-and-plate HE with the increased rib pitch S_p = 4…6 mm (in comparison with the pitch S_p = 2,2mm).

Main material. As a result of experimental studies [3] of heat transfer in ship HE with different fin spacing S_p (finning coefficient β'), the authors obtained data on the thermal efficiency of HE, from which it follows that with a decrease in β' from 11. 74 to 5.41 (accordingly, the step S_p increases from 2.2 to 5.3 mm) at a speed of the oncoming air flow of 2 m/s, the heat transfer coefficient α_a from the air to the outer surface of the HE increases by about 40 %, and the heat load decreases by about 25%. In spite of the fact that increase of fins pitch from 2.2 to 4...6 mm leads to reduction almost in 2 times of total external surface of HE at the same dimensions, due to growth of α_a in 1.4 times there appears a possibility to reduce by 30...40 % energy losses in shipboard MRS due to external irreversibility in the refrigeration cycle. Let us give a substantiation of reduction of these losses.

Heat load Q_0 on HE is determined by the heat transfer surface area F_a and heat exchange intensity, which is characterised by the heat transfer coefficient k

$$k = Q_0/(F_a \cdot \theta). \quad (1)$$

Here θ is the average logarithmic temperature difference between air and refrigerant. Usually for HE of shipboard MRS θ is within the limits: for AC – 8...10 ºC, for ACC – 10...13 ºC [2, 4].

Increasing the heat transfer coefficient from the air to the outer surface of the HE by 30...40 % allows to increase the heat transfer coefficient k by the same amount [2]. As follows from expression (1), θ will decrease by 30...40 % with unchanged Q_0 and F_a. For simplification of calculations we take θ = 10 ºC, and its reduction - 30 %. At unchanged air inlet temperatures t_{v1} and outlet t_{v2}, from HE and its flow rate G_v, this leads, as calculations show, to an increase in the boiling temperature t_0 and a decrease in the condensation temperature t_c by about 3 ºC. It is known from [4] that increase of t_0 by 1 ºC (at unchanged t_{v1}, t_{v2}, G_v) leads to increase of electric refrigeration coefficient ε_e by 3 %, and decrease of t_c by 1 ºC - to increase of ε_e by 1 %. Consequently, if t_0 increases and t_c decreases by 3 ºC, ε_e will increase by about 12 %. If Q_0 remains unchanged, the power consumed by the compressors will decrease by about the same amount (12 %) and, consequently, the fuel consumption associated with cold production will decrease by 12 %.

Conclusions. The use of HE having a unified tube-and-plate surface with a fin spacing of 4...6 mm allows reducing fuel consumption by shipboard MRS by about 12 % in comparison with the same surface having a fin spacing of 2.2 mm.

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УДК 621. 51

DETERMINATION OF PARAMETERS AT TRANSIENT MODES (START-UP, SHUTDOWN) OF MARINE HERMETIC COMPRESSOR UNITS

Olena V. Lytosh
Ph. D., associate professor
Admiral Makarov National University of Shipbuilding,
Mykolaiv, Ukraine
olena.lytosh@nuos.edu.ua

Abstract. Special studies have been carried out, which allow to determine the parameters and investigate the processes occurring during transient modes (start-up, stop) of hermetic compressor units (HCU) operating on refrigerant. Shipboard HCU were tested. The conducted experiments