UDC 621.565
DOI: 10.25206/2588-0373-2020-4-3-28-37

COMPUTER SIMULATION OF ANNUAL WORK CYCLE OF COMBINED REFRIGERATION SYSTEM USING NIGHT RADIATIVE COOLING

A. P. Tsoy[1], A. V. Baranenko[2], A. S. Granovskiy[1], D. A. Tsoy[2], D. A. Koretskiy[1], R. A. Jamasheva[1]

[1]Almaty Technological University,
Kazakhstan, Almaty, Tole Bi Str., 100, 050012
[2]ITMO University,
Russia, Saint Petersburg, Kronverkskiy Ave., 49, 197101

Evaluation of energy efficiency of a combined cooling system that uses night radiative cooling together with refrigerating machine with accumulation of cold without a phase transition and the supply of liquid coolant (propylene glycol) to the air cooler is performed based on the results of computer simulation. In the cooling system located in Kostanay (Kazakhstan), there are radiators (12 m^2) that cool the coolant at night, as well as a conventional vapor compression refrigerating machine with a reciprocating compressor. The cooling system is used to maintain air temperature at the level of 0±1 °C in a small refrigeration chamber (36 m^3) with a low value of heat emission from stored products and the absence of other operational heat influx. It is found that 78,8 days a year the cooling system can maintain the required temperature due to the operation of radiators without turning on the refrigerating machine. This saves 242 kWh of electricity. Thus, the combined refrigeration system provides 7,6 % reduced energy consumption, and also reduces physical deterioration of the refrigerating machine compressor for the annual cycle, which should reduce the financial costs for operating the refrigeration warehouse.

Keywords: Radiative cooling, refrigeration, free cooling, cold storage.

Acknowledgments

This work is prepared under the project 0118PK00535, implemented on the basis of grant AP05130918 / ГФ, allocated under the program of the Ministry of Education and Science of the Republic of Kazakhstan for scientific and (or) scientific and technical projects for 2018–2020.

References

1. Dzhenblat S. S., Volkova O. V. Osnovy i perspektivy primeneniya passivnogo radiatsionnogo okhlazhdeniya [Fundamentals and perspectives of the use of passive radiation cooling] // Kholodil'naya tekhnika. *Kholodilnaya Tekhnika*. 2019. No. 9. P. 36–43. (In Russ.).
2. Liu J., Zhou Z., Zhang J. [et al.]. Advances and challenges in commercializing radiative cooling // Materials Today Physics. 2019. Vol. 11. 100161. DOI: 10.1016/j.mtphys.2019.100161. (In Engl.).
3. Zhao D., Aili A., Zhai Y. [et al.]. Radiative sky cooling: Fundamental principles, materials, and applications // Applied Physics Reviews. 2019. Vol. 6 (2). 021306. DOI: 10.1063/1.5087281. (In Engl.).
4. Ahmad M. I., Jarimi H., Riffat S. Nocturnal Cooling Technology for Building Applications. Springer, Singapore, 2019. 77 p. (In Engl.).
5. Zhang K., Zhao D., Yin X. [et al.]. Energy saving and economic analysis of a new hybrid radiative cooling system for single-family houses in the USA // Applied Energy. 2018. Vol. 224. P. 371–381. DOI: 10.1016/j.apenergy.2018.04.115. (In Engl.).
6. Zhao D., Ailil A., Zhai Y. [et al.]. Yang, Subambient cooling of water: toward realworld applications of daytime radiative cooling // Joule. 2019. Vol. 3. P. 111–123. DOI: 10.1016/j.joule.2018.10.006. (In Engl.).
7. Tsoy A. P., Granovskiy A. S., Baranenko A. V. [et al.]. Effectiveness of a night radiative cooling system in different geographical latitudes // AIP Conference Proceedings. 2017. Vol. 1876. 020060. DOI: 10.1063/1.4998880. (In Engl.).
8. Zhu K., Li X., Campana P. E. [et al.]. Techno-economic feasibility of integrating energy storage systems in refrigerated warehouses // Applied Energy. 2018. Vol. 216. P. 348–357. (In Engl.).
9. Tsoy A. P., Granovskiy A. S., Tsoy D. A. [et al.]. Modelirovaniye raboty ustanovki s radiatsionnym okhlazhdeniyem dlya konditsionirovaniya vozdukha [Simu-lation of radiation cooling system for air conditioning] // Vestnik mezhdunarodnoy akademii kholoda. *Journal of International Academy of Refrigeration*. 2019. No. 3. P. 3–14. DOI: 10.17586/1606-4313-2019-18-3-3-14. (In Russ.).
10. Raspisaniye pogody [Weather schedule] // Arkhiv dannykh o pogode po gorodam mira. 2019 [Archive of Weather Data for Cities in the World. 2019]. URL: http://rp5.kz (accessed: 19.02.2020). (In Russ.).

TSOY Alexandr Petrovich, Candidate of Technical Sciences, Professor of Mechanization and Automation of Manufacturing Processes Department, Almaty Technological University (ATU), Almaty, Kazakhstan.
SPIN-code: 5233-6512
AuthorID (RSCI): 1073647
AuthorID (SCOPUS): 57195570143
BARANENKO Aleksandr Vladimirovich, Doctor of Technical Sciences, Professor, Advisor to Rector's Office, ITMO University, Saint Petersburg.

SPIN-code: 5621-0524
AuthorID (RSCI): 173759
ORCID: 0000-0003-3675-9513
AuthorID (SCOPUS):6602940582
GRANOVSKIY Alexandr Sergeevich, Master of Technical Sciences, Junior Researcher, ATU, Almaty, Kazakhstan.
SPIN-code: 3361-3000
AuthorID (RSCI): 792063
AuthorID (SCOPUS): 57195570324
TSOY Diana Alexandrovna, Graduate Student of Cryogenic Engineering Department, ITMO University, Saint Petersburg.
AuthorID (SCOPUS): 57195566340
KORETSKIY Dmitriy Anatolyevich, Undergraduate student of Faculty of Engineering and Information Technology, Laboratory Assistant, ATU, Almaty, Kazakhstan.
SPIN-code: 5469-2080
AuthorID (RSCI): 1073659
JAMASHEVA Rita Adilovna, PhD Candidate of Faculty of Engineering and Information Technology, Lecturer, ATU, Almaty, Kazakhstan.
SPIN-code: 9882-2419
AuthorID (RSCI): 1073937

Address for correspondence: teniz@bk.ru

For citations

Tsoy A. P., Baranenko A. V., Granovskiy A. S., Tsoy D. A., Koretskiy D. A., Jamasheva R. A. Computer simulation of annual work cycle of combined refrigeration system using night radiative cooling // Omsk Scientific Bulletin. Series Aviation-Rocket and Power Engineering. 2020. Vol. 4, no. 3. P. 28–37. DOI: 10.25206/2588-0373-2020-4-3-28-37.

Received March 23, 2020.
© A. P. Tsoy, A. V. Baranenko, A. S. Granovskiy, D. A. Tsoy, D. A. Koretskiy, R. A. Jamasheva