Thermodynamic efficiency investigation for a micro-CHP system featuring a gas microturbine with an altered process sequence

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We consider a cogeneration plant featuring a gas microturbine with an altered process sequence. We describe the flow diagram of our plant, its principle of operation and primary advantages: high heat energy conversion efficiency, fuel combustion at atmospheric pressure, absence of either a combustion chamber proper or a high-temperature microturbine gas-to-air heat exchanger. We supply thermodynamic parameter calculation results for our diagram operating in both traditional and low-temperature heating systems. Analysis of the results obtained shows that this cogeneration plant is feasible and is able to satisfy heating and electricity demands with microturbine parameters being characteristic of commercial centrifugal compressors used in conjunction with internal combustion engines. As a conclusion, we select the optimum microturbine pressure ratio to be $\pi_t = 1.6...1.8$, since it achieves a high micro-CHP thermal output with acceptable microturbine parameters.

Keywords: *micro-CHP, reverse Brayton cycle, gas microturbine.*

REFERENCES

[1] Ametistov E.V., Klimenko A.V., Leontev A.I., Milman O.O., Favorskiy O.N., Fedorov V.A. et al. *Izvestiya RAN. Energetika — Proceedings of the Russian Academy of Sciences. Power Engineering Journal*, 2003, no. 1, pp. 107–117.

[2] Favorskiy O.N., Leontev A.I., Fedorov V.A., Milman O.O. *Teploenergetika — Thermal Engineering*, 2003, no. 9, pp. 19–21.

[3] *Innovatsii v Rossii. Tekhnologicheskaya platforma "Malaya raspredelennaya energetika"* [Innovations in Russia. The "Small-scale distributed power generation" technology platform].
Available at: http://innovation.gov.ru/node/3459 (accessed 16 March, 2016).

[4] Pehnt M., Cames M., Fisher C. et al. *Micro Cogeneration. Towards Decentralized Energy System*. Berlin; Heidelberg, Springler-Verlag, 2006, 346 p.

[5] Beith R. *Small and micro combined heat and power (CHP) systems. Advanced design, performance, materials and applications*. Woodhead Publishing, Ltd., 2011, 528 p.

[6] Tumashev R.Z., Bodrov N.G. *Inzhenernyy zhurnal: nauka i innovatsii — Engineering Journal: Science and Innovation*, 2012, iss. 10.
DOI: 10.18698/2308-6033-2012-10-401

[7] Vermes G., Beér J.M. *Ambient Pressure Gas Turbine System*. US Patent, no. 6298654 B1, 2001.

[8] *GOST 54961–2012. Sistemy gazoraspredelitelnye. Seti gazopotrebleniya. Obshchie trebovaniya k ekspluatatsii. Ekspluatatsionnaya dokumentatsiya* [State Standard 54961–2012. Gas distribution systems. Gas networks. General requirements for usage]. Moscow, Standartinform Publ., 2013, 53 p.

[9] Lipikhin E.G., Shevelev D.V. *Elektronnyy zhurnal: nauka, tekhnika i obrazovanie — Electronic journal: science, technology and education*, 2015, no. 3. Available at: http://nto-journal.ru/uploads/articles/ff61bf9b2c5843c36aecfef235352660.pdf

[10] *GOST R 53637–2009. Turbokompressory avtotraktornye. Obshchie tekhnicheskie trebovaniya i metody ispytaniy* [State Standard R 53637–2009. Motor and tractor centrifugal compressors. General technical requirements and test methods]. Moscow, Standartinform Publ., 2010, 12 p.

[11] *Proektnaya dokumentatsiya dlya kondensatsionnykh kotlov BuderusLoganoPlus* [Project documentation for Buderus Logano Plus condensing boilers]. Available at: http://www.buderus.ru

[12] *GOST 30735–2001. Kotly otopitelnye vodogreynye s teploproizvoditelnostyu ot 100 kVt do 4 MVt. Obshchie tekhnicheskie usloviya* [State Standard 30735–2001. Heating water boilers with heating capacities between 100 kWt and 4 MWt. General technological conditions]. Introduced Jan 01 2003. Moscow, Standartinform Publ., 2002.

[13] *GateCycle, General Electric*. Available at: https://getotalplant.com/GateCycle/docs/GateCycle/index.html (accessed 04 March, 2016).

[14] Tsanev S.V., Burov V.D., Remezov A.N. *Gazoturbinnye i parogazovye ustanovki teplovykh elektrostantsiy* [Gas turbine and combined cycle plants of thermal power stations]. Moscow, Moscow Power Engineering Institute Publ., 2009, 584 p.

[15] Lipikhin E.G., Shevelev D.V. Vliyanie stepeni ponizheniya davleniya gaza na oblik protochnoy chasti mikroturbiny kogeneratsionnoy ustanovki [Effect of pressure ratio degree on the wheelspace layout of a cogeneration plant microturbine]. *Tr. Region. Nauchno-tekhn. konf. Studentov, aspirantov i molodykh uchenykh "Naukoemkie tekhnologii v priboro- i mashinostroenii i razvitie innovatsionnoy deyatelnosti v vuze"* [Proc. of the "Knowledge-intensive technologies in instrumentation and mechanical engineering and innovative activity development in higher education institutions: Regional Scientific and Technological Conference of students, postgraduates and young scientists]. April 19th–21st, 2016, vol. 1. Kaluga, Bauman Moscow State Technical University, 2016, pp. 124–129.

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