Using integral transform method to solve the problem of cooling in a system of coaxial cylinders

© I.S. Plotnikov, V.M. Puchkov

Bauman Moscow State Technical University, Moscow, 105005, Russia

The article presents an analytical solution to the problem of determining temperature field distribution in a system of coaxial cylinders as it cools. We developed a mathematical model for non-steady state thermal conductivity processes, which considers perfect contact between interacting bodies. We investigated the matter of simplifying the model by replacing thin cylindrical walls with flat infinite plates of the same thickness. We obtained a solution by means of integral transforms in Cartesian and cylindrical coordinates. The study deals with a mathematical problem of describing the interface between an internal bar of the system, defined in a cylindrical coordinate system, and an adjacent flat infinite plate, defined in Cartesian coordinates in the simplified model. We plotted the results on temperature field curves in the system of coaxial cylinders for various moments in the evolution of the cooling process. This solution is valid under the following conditions: a low ratio of cylindrical layer thickness to the radius of curvature of the actual cylinder axis, optical opacity of all layers and axial symmetry of the model geometry and boundary conditions.

Keywords: *integral transform method, system of coaxial cylinders, non-steady state thermal conductivity, matching boundary conditions*

REFERENCES

[1] Esman R.I., Zhmakin N.P., Shub L.I. *Raschety protsessov litya* [Computing parameters of casting processes]. Minsk, Vysshaya Shkola Publ., 1977, 264 p.

[2] Esman R.I., Ustimovich V.A. *Energetika. Izvestiya vysshikh uchebnykh zavedeniy i energeticheskikh obedineniy SNG — Energetika. Proceedings of CIS higher education institutions and power engineering associations*, 2007, no. 6, pp. 32–36. Available at: http://energy.bntu.by/jour/article/view/590 (accessed April 18, 2017).

[3] Tugolukov E.N. *Reshenie zadach teploprovodnosti metodom konechnykh integralnykh preobrazovaniy pri avtomatizirovannom proektirovanii tekhnologicheskogo oborudovaniya khimicheskoy promyshlennosti* [Solving thermal conductivity problems using finite integral transforms for computer-aided design of chemical industry processing equipment]. Tambov, TSTU Publ., 2006, 116 p.

[4] Koshlyakov N.S., Gliner E.B., Smirnov M.M. *Uravneniya v chastnykh proizvodnykh matematicheskoy fiziki* [Partial differential equations in mathematical physics]. Moscow, Vysshaya Shkola Publ., 1970, 712 p.

[5] Kartashov E.M. *Analiticheskie metody v teorii teploprovodnosti tverdykh tel* [Analytical methods in thermal conductivity theory of solids]. 3rd ed. Moscow, Vysshaya Shkola Publ., 2001, 550 p.

[6] Repin O.A., Zaikina S.M. *Vestnik Samarskogo gosudarstvennogo tekhnicheskogo universiteta. Seriya: Fiziko-matematicheskie nauki - Journal of Samara State Technical University, Ser. Physical and Mathematical Sciences*, 2011, no. 2 (23), pp. 8–16. DOI: 10.14498/vsgtu913 (accessed April 02, 2017).

[7] Kilbas A.A., Saigo M. H-Transforms: Theory and Applications. *Series on Analytic Methods and Special Functions*. Boca Raton, CRC Press, 2004, vol. 9, pp. 389.

[8] Tikhonov A.N., Samarskiy A.A. *Uravneniya matematicheskoy fiziki* [Equations of mathematical physics]. Moscow, Lomonosov Moscow State University Publ., 2004, 800 p.
[9] Yanovsky I. *Partial Differential Equations: Graduate Level Problems and Solutions.* Create Space Independent Publishing Platform, 2014, 396 p.
[10] Samarskiy A.A., Vabishchevich P.N. *Vychislitelnaya teploperedacha* [Computational heat transfer]. Moscow, Editorial URSS, 2014, 784 p.

Puchkov V.M. (b. 1950) graduated from Moscow Higher Technical School in 1974. Cand. Sc. (Eng.), Assoc. Professor, Department of Rocket Launch Complexes. Author of over 80 scientific publications in the field of heat and mass transfer.
e-mail: pvmpuchkov@yandex.ru

Plotnikov I.S. (b. 1994), fifth year student, Department of Rocket Launch Complexes, Bauman Moscow State Technical University. e-mail: pvmpuchkov@yandex.ru