УДК 681.12

S. Tkachenko
O. Vlasenko
V. Zadoyan

COOLING (HEATING) RATE OF SUGAR SOLUTION AT HEIGHT UNDER CONDITIONS OF FORCED CONVECTION

Vinnytsia National Technical University

Abstract
The rate of cooling (heating) of experimental liquids was studied separately for five thermocouples located at different heights of the experimental probe.

Non-stationary thermal conductivity corresponds to a thermal regime unstable in time, created by this or that thermal action on the body or environment. Non-stationary thermal conductivity is characterized by the fact that the temperature changes not only from point to point, but also over time. Non-stationary thermal conductivity occurs during heating or cooling of bodies, as well as when starting or stopping heat exchange devices, power units, etc.

The experimental results are presented on the study of the rate of cooling (heating) of experimental liquids separately for five thermocouples located at different heights of the experimental probe under conditions of forced convection.

Key words: cooling (heating) rate, thermocouple, excess temperature, regular thermal regime.

Introduction

Among the practical problems of non-stationary thermal conductivity, two groups of processes are of great importance when: - the system moves to a state of thermal equilibrium; - the temperature of the system undergoes periodic changes. The first group includes the processes of heating or cooling bodies placed in an environment with given parameters, for example, heating a billet in a furnace, cooling a part that is being hardened, etc. The second group includes processes occurring in periodically operating heaters, for example, air heating in regenerators. This group also includes the processes of heating or cooling of enclosing structures, structures and buildings with periodic changes in the temperature of the outside air [1-2].

The purpose of the work: to determine the rate of cooling (heating) of the experimental liquids separately for each thermocouple located on the probe at different heights, under conditions of forced convection.

Research results

Research is carried out on an experimental stand in the system "environment I - body II", where "environment I" is water, and "body II" is the investigated liquid medium in a thin metal cylindrical shell under conditions of forced convection.

The temperature distribution along the heat exchange surface is studied under the condition of natural convection, the hot liquid is cooled, and the cold one is heated. During the study, probes with five thermocouples were immersed in the inner and outer vessels of the experimental stand [3], which record the temperature values at different heights, namely: 3, 27, 44, 64, 90 mm.

In tables 1-2 and fig. 1 – 2 show the experimental results for a sugar solution c=20% during heating and cooling, under the conditions of the location of the thermocouple at a height of 3, 27, 44, 64, 90 mm. The curve represents the approximation of the experimental data of excess temperature in the form of a function $Ln\vartheta = m \cdot \tau + C$, where m is the rate of cooling (heating), C is the coefficient of the equation, R2 is the coefficient of determination. The obtained curve has a linear character, which corresponds to a regular thermal regime.

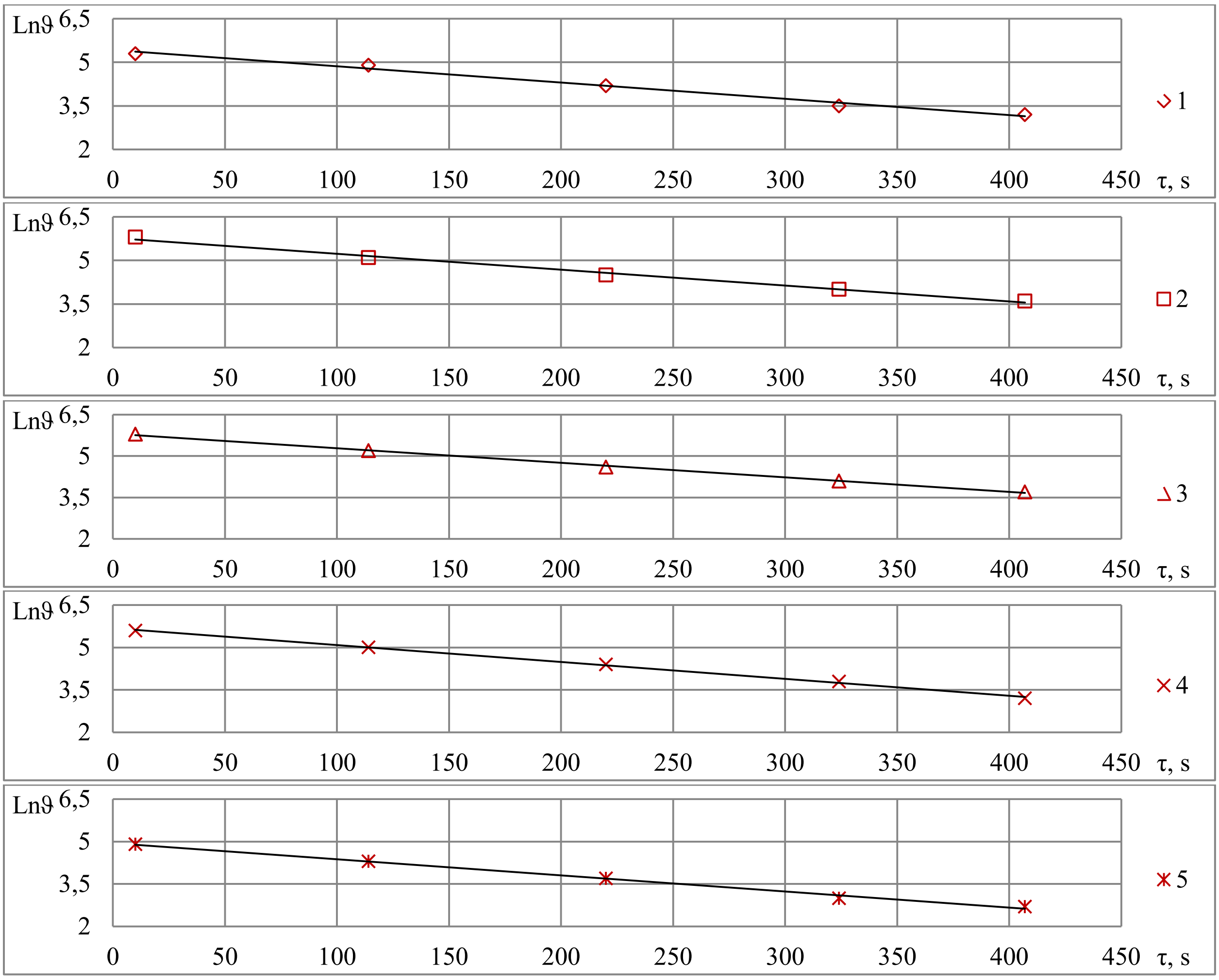
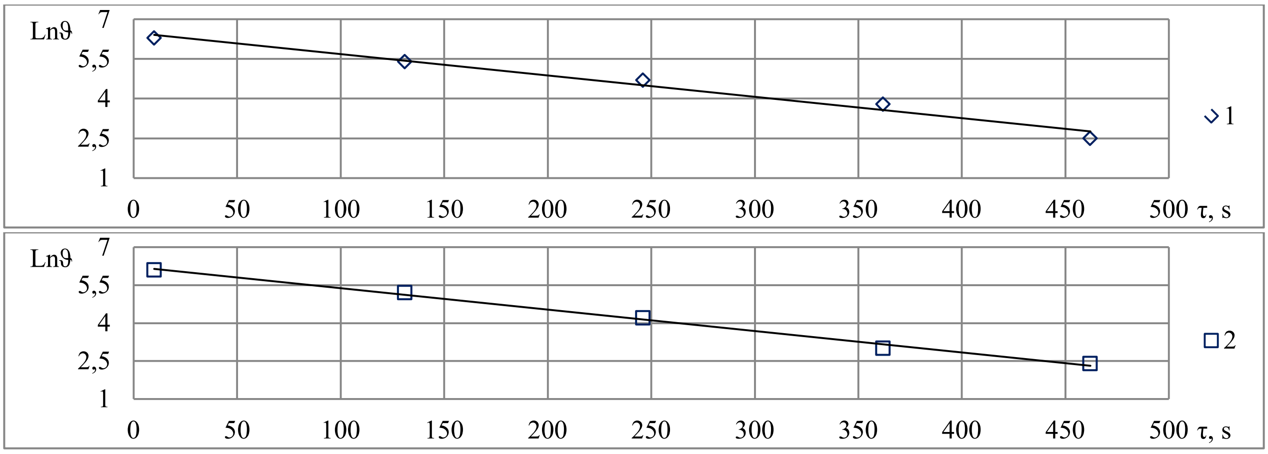


Fig. 1. Comparison of the value of the excess temperature for each thermocouple with the average volume value when heating the sugar solution c=20%. Location of thermocouples by height: 1 – 3mm, 2 – 27mm, 3 – 44mm, 4 – 64mm, 5 – 90mm.

Table 1 – Heating of sugar solution c=20%

№	The height of the location of the thermocouple h, mm	A function of the form Lnϑ=m·τ + C	Coefficient of determination R^2
1	90	y = -0,0056x + 5,4217	R^2 = 0,9897
2	64	y = -0,0055x + 5,7802	R^2 = 0,9945
3	44	y = -0,0053x + 5,8166	R^2 = 0,998
4	27	y = -0,0060x + 5,6824	R^2 = 0,9981
5	3	y = -0,0057x + 4,9438	R^2 = 0,9953



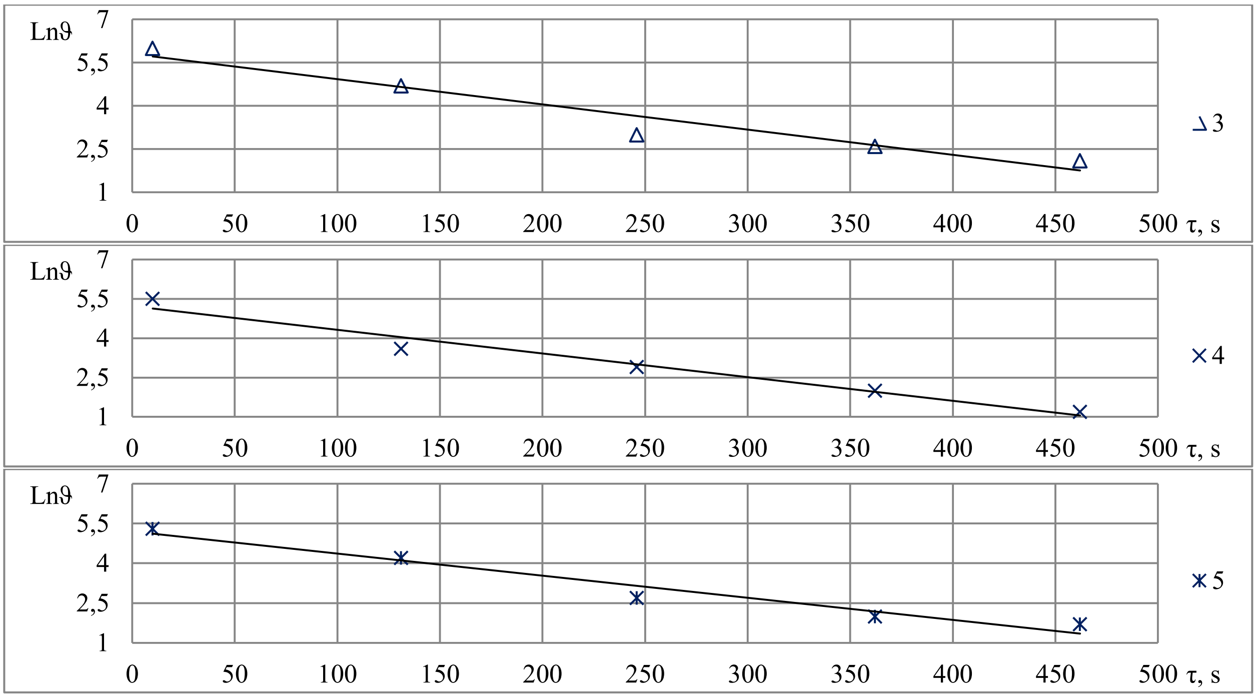


Fig. 2. Comparison of the value of the excess temperature for each thermocouple with the average volume value when cooling the sugar solution c=20%. Location of thermocouples by height: 1 – 3mm, 2 – 27mm, 3 – 44mm, 4 – 64mm, 5 – 90mm.

Table 2 – Cooling of sugar solution with = 20%

№п/п	The height of the location of the thermocouple h, mm	A function of the form Lnϑ=m·τ + C	Coefficient of determination R^2
1	90	y = -0,0081x + 6,4946	R^2 = 0,9798
2	64	y = -0,0085x + 6,2305	R^2 = 0,9952
3	44	y = -0,0088x + 5,8048	R^2 = 0,9410
4	27	y = -0,0090x + 5,2243	R^2 = 0,9665
5	3	y = -0,0083x + 5,1974	R^2 = 0,9571

The experimental results are presented on the study of the rate of cooling (heating) of experimental liquids separately for five thermocouples located at different heights of the experimental probe under conditions of forced convection. It is obvious that the natural logarithm of the excess temperature for all points of the body changes over time according to a linear law, which is characteristic of a regular thermal regime for solid bodies and a system of solid bodies.

Conclusions

1. Studies of the rate of cooling (heating) of sugar solution c=20% were carried out on an experimental stand in the system "environment I - body II", where "environment I" is water, and "body II" is the investigated liquid medium in a thin metal of a cylindrical shell under conditions of forced convection.

2. The experimental results of the study of the rate of cooling (heating) of experimental liquids separately for five thermocouples located at different heights of the experimental probe under conditions of forced convection are presented. It is obvious that the natural logarithm of the excess temperature for all points of the body changes over time according to a linear law, which is characteristic of a regular thermal regime for solid bodies and a system of solid bodies.

REFERENCES

1. Isachenko V. P. Heat transfer. Textbook for universities, ed. 3 - e, processing. and additional / V. P. Isachenko,V. A. Osypova, A. S. Sukomel. - M.: "Energy", 1975. - 488 p.
2. G. M. Kondratiev Regular heat regime / G. M. Kondratiev. - M.: Gosudarstvennoe izdatelsto tekhniko-teoreticheskoe literatury, 1954. - 408 p.
3. Tkachenko S.Y. New methods for determining the intensity of heat exchange in organic waste processing systems: monograph / S.Y. Tkachenko, N.V. Pishenina. – Vinnytsia: VNTU, 2017. – 148 p.

Tkachenko Stanislav – Dr. Sc. (Eng.), professor of the Department of Thermal Power Engineering, Vinnytsia National Technical University, Vinnytsia, e-mail: stahit6937@gmail.com.

Vlasenko Olha – Researcher of the Department of Thermal Power Engineering, Vinnytsia National Technical University, Vinnytsia, e-mail: olgakytsak7@gmail.com.

Zadoyan Vladislav – student of the Department of Thermal Power Engineering, Vinnytsia National Technical University, Vinnytsia, e-mail: Vlad.zadoian@gmail.com.