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CONTROLLABILITY ESTIMATION FOR HEATING SYSTEMS WITH INFRARED TUBE HEATERS

The method for controllability estimation for heating systems with infrared tube heaters is considered in the article
Keywords: *infrared tube heater, reliability, controllability, method for estimation*

1. Introduction

The researches, described in the article is referred to the field of power engineering.

The actual direction of heating development is smart decentralization of the systems.

It results on the account of use traditional and comparatively new sources of heat supply of low-capacity as well.

The subjects of the study are heat and mass transfer processes in the infrared tube heaters in industrial apartment that are equipped with these heaters. The object of investigation is the heating systems with infrared tube heaters. They simultaneously are the sources of heat supply and heaters. At decentralization of heating systems of industrial and agricultural enterprises these systems provide considerable capital investment economy and also current expenses on fuel. The reliability of these systems one of the most important requirements to them both as on the design point as in the process of exploitation.

Reliability is important property of heating systems and can be determined as an object property to perform the prescribed functions in the prescribed volume at certain conditions of operation [1]. It is the complex property that can consists of single properties. The single properties of reliability include stabilability, controllability, survivability and safety. These properties were investigated in works [2,3,4] and reflected the important side of functioning objects. Necessity for including these properties in the notion «reliability» is caused by specific features of heating systems.

Research methodology of heating systems with infrared tube heaters implies the study of such a single property as controllability. Controllability can be determined as an object property to maintain normal operating conditions by control.

The estimation of controllability of the heating systems with infrared tube heaters was carried out on the basis of existing mathematical models. For sufficiently full reflection of real processes of development and operation of the modeled objects the mathematical models constructed must take into account main properties of these objects that are significant from the viewpoint of the problems solved.

At present moment there are no definite statements about method of estimation of controllability of the heating systems with infrared tube heaters. There are useful mathematical methods for solving the reliability problems in the investigation of the reliability of power systems in the modern theory of reliability. Some of these methods do not allow to reliability estimation and increase it saving capital costs for equipment and exploitation costs on fuel and energy resources for heating systems with infrared tube heaters. There is a need to introduce the controllability indices. Thus, the direction of the work is actual in scientific as well as in technic.

2. Problem formulation

A general problem of the heating systems with infrared tube heaters consists in determining the given values of controllability indices during the considered time period by using the available means and possibilities.

3. Main part

3.1. Description of literature sources

Mathematical model heat transfer and air flows is proposed [5,6]. Algorithm for numerical solving of hydraulic circuit is formulated.

Special infrared tube heaters are considered that satisfy radiant and convective heat capacity with heating force air [7].

The new method for controllability estimation of these systems was worked out.

We consider the let Ω of elementary events ω_i $\Omega = \bigcup \omega_i$, where i-order number of the event.

The definition of the complex controllability indices was proposed as

$$k = \sum_i \frac{Q_i^R - \Delta Q_i}{Q_i^R} \times \tau_i ,$$

$$Q_i^R = Q_{hi}^R + Q_{vi}^R ,$$

$$Q_{hi}^{R} = Q_{hi}^{R}\left(t_{i}^{ext}\right) ,$$

$$Q_{vi}^{R} = Q_{vi}^{R}\left(t_{i}^{ext}\right) ,$$

$$\Delta Q_{i} = Q_{hi}^{R} + Q_{vi}^{R} - Q_{hi} - Q_{vi} ,$$

where: Q_{i}^{R} - required heat capacity at event i; Q_{hi}^{R}, Q_{vi}^{R} - required capacity for heating and ventilation respectively; t_{i}^{ext} - external temperature at event i; Q_{hi}, Q_{vi} - real capacity for heating and ventilation respectively; ΔQ_{i} - heat shortage at event i.

For calculating of values Q_{hi}, Q_{vi} the mathematical model of hydraulic and thermal regimes was obtained.

The model can be represented as differential equations:

$$\frac{dy_{j}}{dx} = f_{j}\left(y_{1}, y_{2}, \ldots, y_{n}, \ldots x\right), \quad j=1,2,\ldots,n , \qquad (1)$$

where: x – linear coordinate of heater $x \in [0, \ell]$; y_{j} - hydraulic or thermal parameter of heater with number j.

Initial conditions are

$$y_{j}(0) = y_{j0}, \quad j=1,2,\ldots(n-1) , \qquad (2)$$

and the additional condition

$$\int_{0}^{\ell} y_{1}'(x)dx + \phi\left[y_{n}(\ell)\right] = 0 , \qquad (3)$$

where: $y_{1}'(x)$ - the derivative of pressure along tube heater; ϕ - the known function.

For every elementary event with external temperature t_{i}^{ext} it is numerical integrated the differential system (1) with condition (2) and any value $y_{n}(0)$. Then with the help of random search it is calculated $y_{n}(0)$ that satisfy condition (3). Knowledge of the numerical values of $y_{j}(x)$ gives possibility to calculate capacity of heating and ventilation and to calculate the complex controllability indices.

3.2. Conclusions

The method for controllability estimation for heating systems with infrared tube heaters was worked out. The definition of the complex controllability indices was proposed. The method is based on the mathematical model of hydraulic and thermal regimes for heating systems with infrared tube heaters.

References

1. Надежность систем энергетики. Терминология [Текст] : Сб. рекомендуемых терминов. – М.: Наука, 1980. – Вып.95. – 44с.
2. Ионин, А.А. Надежность систем тепловых сетей [Текст] / А.А. Ионин. – М.: Стройиздат, 1989. – 268 с.
3. Руденко, Ю.Н. Надежность систем энергетики [Текст] / Ю.Н. Руденко, И.А. Ушаков. – М.: Наука, 1989. – 325 с.
4. Сухарев, М.Г. Надежность систем энергетики и их оборудования [Текст] : Справочник в 4-х т. / М.Г. Сухарев, С.Г. Бабаев, А.М. Бейлин и А.А. Ионин, В.Ф. Иродов [и др.]; под ред. М.Г. Сухарева // Т.3: Надежность систем газо- и нефтеснабжения. – М.: Недра, 1994. – Кн.2. – 287 с.
5. Иродов, В.Ф. Математическое моделирование элементарного участка системы воздушно-лучистого отопления [Текст] / В.Ф. Иродов, Л.В. Солод., А.В. Кобыща // Вісник Придніпровської державної академії будівництва та архітектури. – Дніпропетровськ: ПДАБтаА, 2001. – №4. – С.41-46.
6. Вячеслав Иродов Расчет температурных удлинений инфракрасного трубчатого газового обогревателя [Текст] : Сб. трудов / Вячеслав Иродов, Валерия Ткачева, Леонтина Солод // Теоретические основы строительства. –№19. – Днепропетровск, 2011. – С. 381-386.
7. Дудкин, К.В. Математическое моделирование трубчатых газовых нагревателей для безопасного нагрева воды в объеме со свободной поверхностью [Текст] : Зб.наук.пр. / К.В. Дудкин, В.В. Ткачева., Ю.В. Бобырь // Будівництво. Матеріалознавство. Машинобудування. – Дніпропетровськ: ПДАБА, 2011. – Вип. 62. – С. 166-170.

ОЦІНКА РЕЖИМНОЇ КЕРОВАНОСТІ СИСТЕМ ТЕПЛОПОСТАЧАННЯ З ІНФРАЧЕРВОНИМИ ТРУБЧАСТИМИ ГАЗОВИМИ НАГРІВАЧАМИ

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У статті розглядається метод оцінки режимної керованості систем теплопостачання зі спеціальними інфрачервоними трубчастими газовими нагрівачами

Ключові слова: інфрачервоний трубчастий газовий обігрівач, надійність, режимна керованість, метод оцінки

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ОЦЕНКА РЕЖИМНОЙ УПРАВЛЯЕМОСТИ СИСТЕМ ТЕПЛОСНАБЖЕНИЯ С ИНФРАКРАСНЫМИ ТРУБЧАТЫМИ ГАЗОВЫМИ НАГРЕВАТЕЛЯМИ

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В статье рассматривается метод оценки режимной управляемости систем теплоснабжения со специальными инфракрасными трубчатыми газовыми нагревателями

Ключевые слова: инфракрасный трубчатый газовый нагреватель, надежность, режимная управляемость, метод оценки

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