Computer-Aided Design of Gas Flow Temperature Measurement Errors

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I. Background

Economical consumption of natural gas is possible only in the condition of its metering at all stages of its transportation and supply to the consumers. The accuracy of such a metering is defined by technical base, normative and metrological base.

A negative factor affecting the accuracy of measuring the flow and volume of natural gas is the presence of heat exchange processes in the metering system, which may lead to the occurrence of additional systematic errors in measuring the gas temperature and, accordingly, the errors in measuring the flow and volume of gas.

The goal of this work is to present the system for computer-aided calculation of additional systematic errors of natural gas temperature measurement. Calculation is made for the data on real working conditions of the gas metering unit.
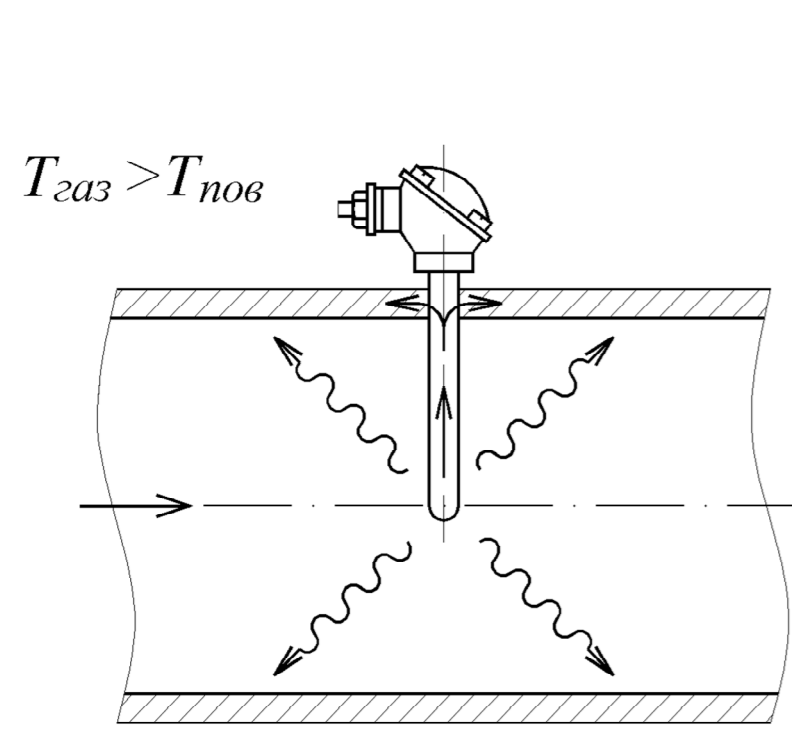
II. Errors of flow temperature measurement

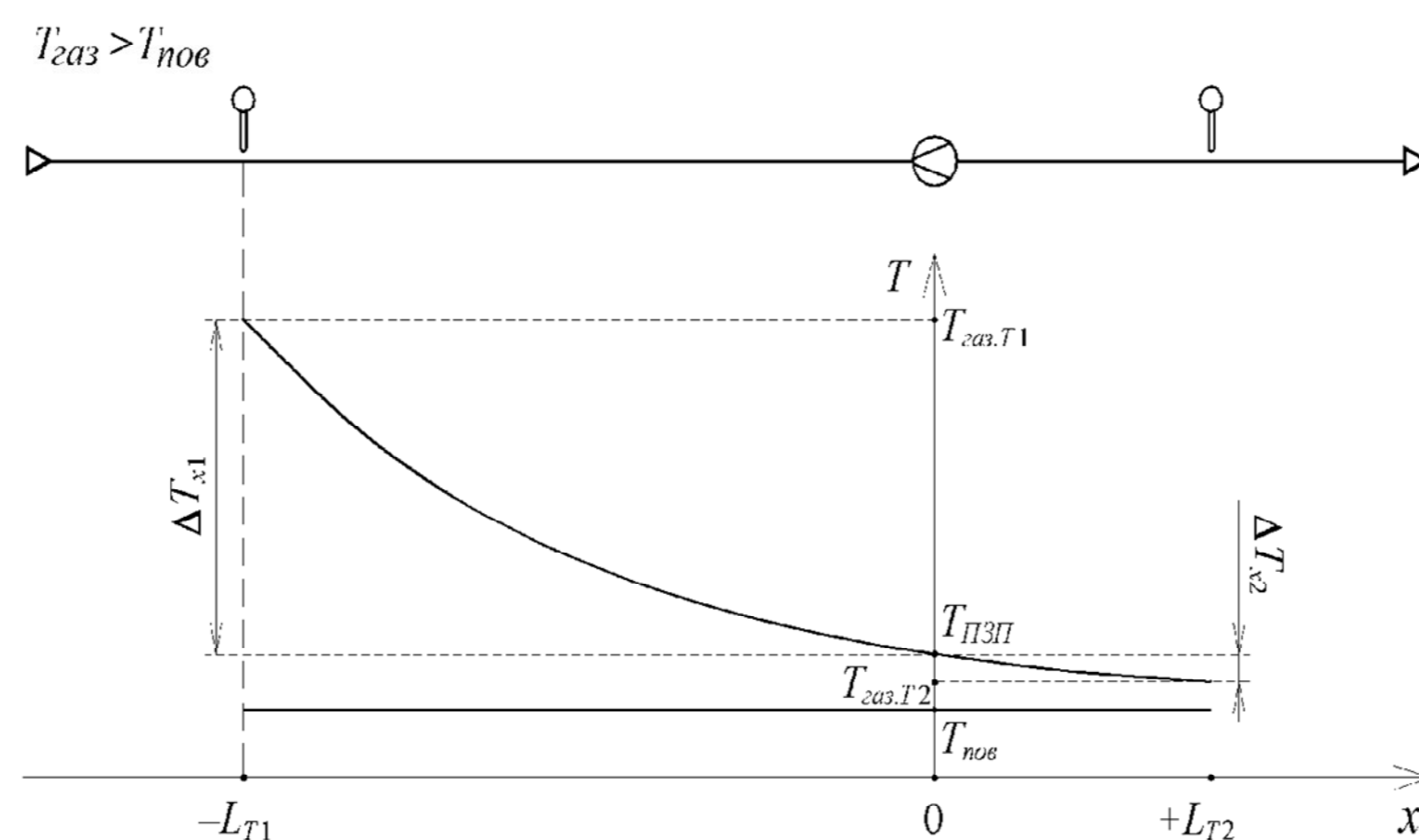Fig.1. the error caused by heat exchange between the thermometer case and the pipe wall (ΔT_T)

Fig.2. The error caused by heat exchange between the pipe wall and the ambient air (ΔT_x).
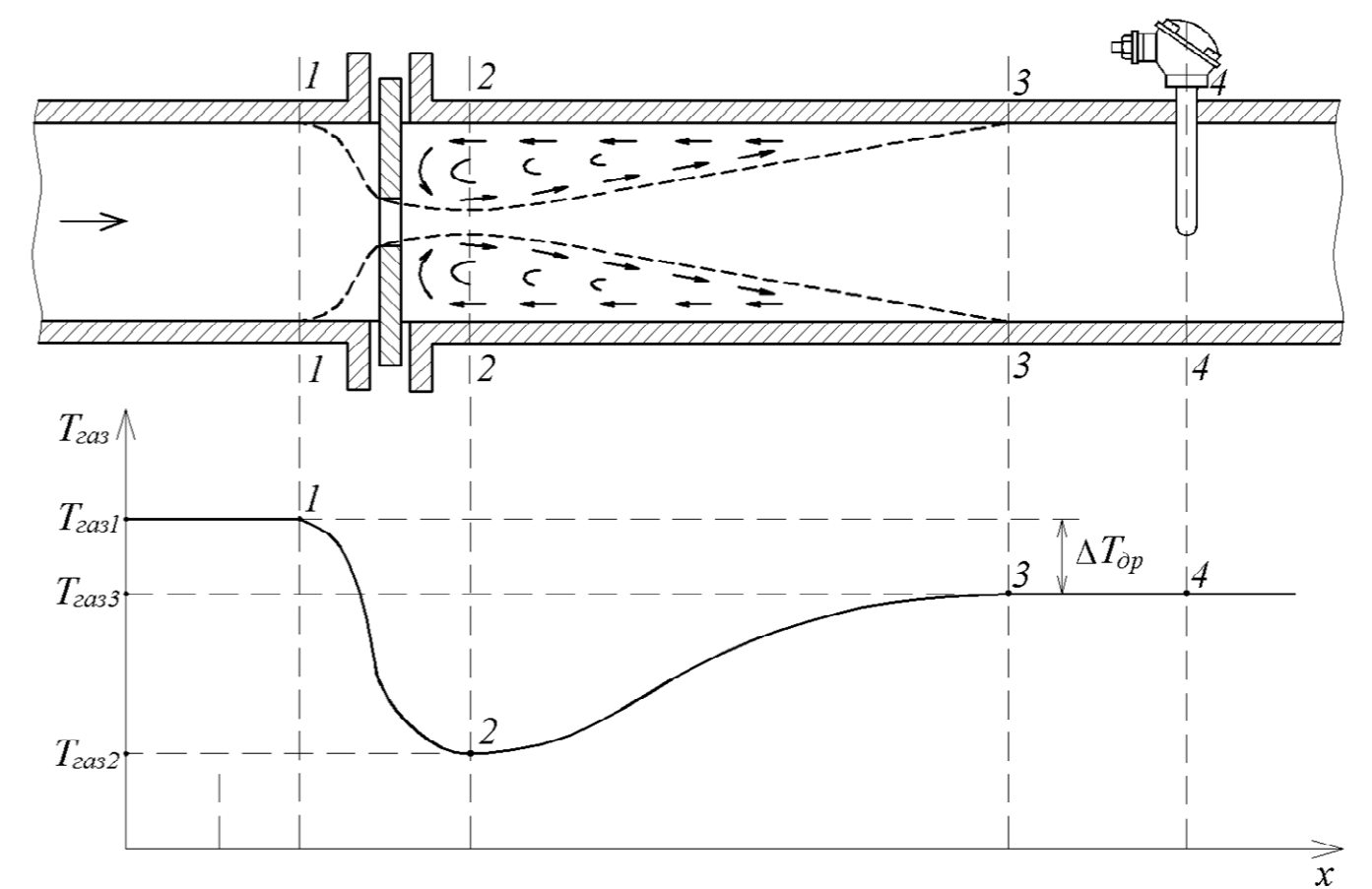

Fig.3. The error caused by temperature decrease as the gas is throttled through the pressure differential device (ΔT_{thr})

III. Computer-aided design of gas flow temperature measurement errors

Calculation of these errors is a complicated process since there is a need to accomplish computation of the gas properties (density, viscosity, isentropic exponent etc.) as well as the heat exchange processes in the pipe. In order to calculate the gas flow temperature measurement errors, various methods can be used:

- calculation by means of a calculator (simple but time consuming and not efficient);

- application of MS Excel (more efficient than the calculator but there is no possibility to accomplish a cycle computation with the exit by a condition "while");

- application of Matlab (efficient but requires special skills from the user).
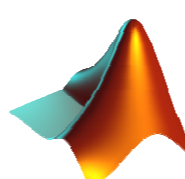
To simplify the process of calculating the errors a special CAD system was developed.

The system was built using the following technologies:

- **HTML (HyperText Markup Language)**. This is the standard markup language for creating web pages and web applications;
- **CSS (Cascading Style Sheets)**. This is a style sheet language used for describing the presentation of a document written in a markup language like HTML;
- **JS (JavaScript)**. This is a language which is also characterized as dynamic, weakly typed, prototype-based and multi-paradigm;
- **PHP (Hypertext Preprocessor)**. This is a server-side scripting language designed for Web development.

Fig.4. Window for entering the parameters of the gas flow.

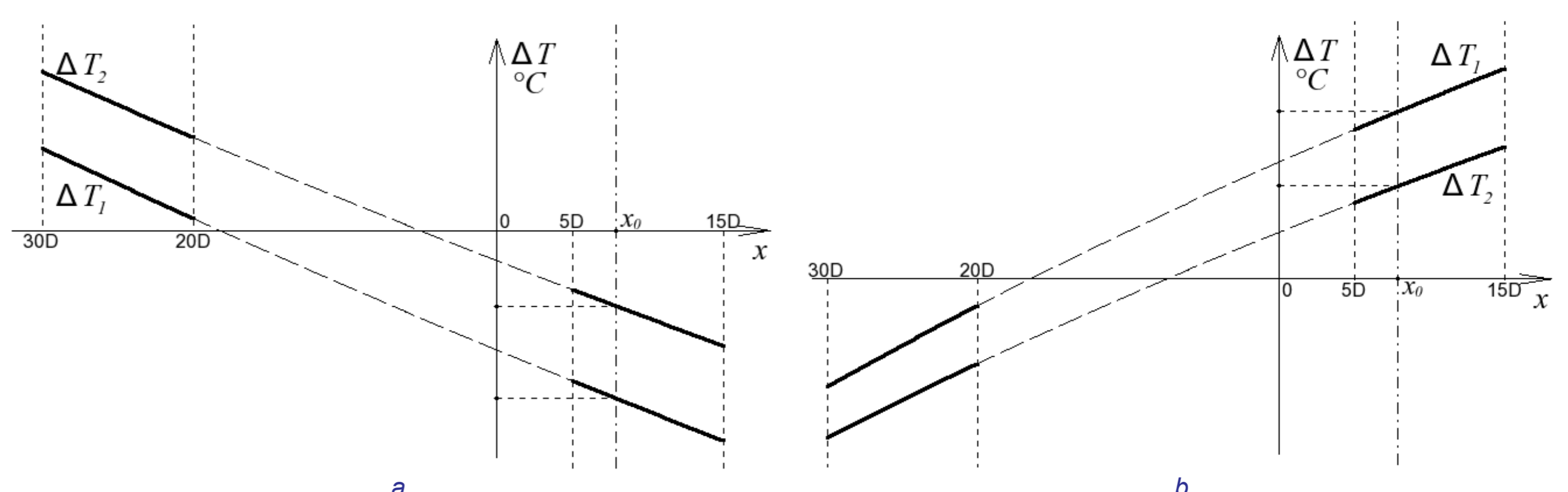Fig.5. Window for entering the parameters of the thermometer.

a

b

Fig.6. Curves of flow temperature measurement error ($\Delta T_T + \Delta T_x$) versus the distance from the primary device (a – winter conditions; b – summer conditions).

After entering all the input data the Calculation button should be pressed. The system will execute the calculations and return a short list of the calculation results together with the curves of the flow temperature measurement error versus the distance from the primary device (see Fig.6).

Conclusion

Application of the developed CAD software simplifies the process of calculating the errors of gas flow temperature measurement.

The short list of the calculation results includes the velocity of the gas flow, the heat flux from the gas to the ambient air, the temperature of the pipe internal surface, the temperature of the pipe external surface and other. The CAD system returns the recommendation on whether there is a need to install the heat insulation for the flow meter or not.