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Odessa National Academy of Food Technologies

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BLACK SEA SCIENCE 2021

Information Technology, Automation and Robotics

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Odessa National Academy of Food Technologies, 2021

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OUTPUT OF DATA OF MECHANICAL CONTROL SYSTEMS FOR THERMAL MOVEMENTS OF STEAM PIPELINES OPERATING AT THERMAL POWER PLANTS INTO A DIGITAL APCS SYSTEM

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Abstract

The conversion of existing mechanical control systems of steam pipeline thermal displacements into a digital control and monitoring system for technological parameters of the tested object, in real time using the APCS software is considered in this scientific paper. A step-by-step algorithm for the practical implementation of signals from sensors of thermal displacements of steam pipelines with analog outputs into the digital system of the automated process control system has been developed. The control system of the thermal displacements of steam pipelines is integrated into the APCS system and operates according to the operating software of the APCS. This topic is relevant in the field of automation and control.

Keywords: sensor, indicators of thermal movements, algorithm, distributed periphery stations, controller, automatic control system for technological processes.

I.Introduction

During the operation of the power unit, the thermal displacements of the steam pipelines can be affected by loads that are not provided for in the design. These loads, first of all, include beyond design movement of equipment, coolant in all operating modes.

To obtain reliable results on operational loads, it is necessary to identify all possible loading factors and develop methods for their determination based on the readings of thermal displacement sensors of steam pipelines.

To measure thermal displacements of steam pipelines, manufacturers produce sensors with analog and digital outputs, as well as ultrasonic sensors.

After connecting the sensors of thermal displacements of steam pipelines to the PTC controller, the system for monitoring the thermal displacements of steam pipelines functions according to the operating software of the PTC.

The introduction of the input of signals of the control system the steam pipelines thermal displacements in the APCS makes it possible to identify all possible loading factors and methods of their determination based on the load indication:

- To identify beyond design thermal displacements of steam pipelines in the "On-line" mode in all operating modes and take into account their real movements.
- Timely identify zones of occurrence of thermal displacements and promptly signal operating personnel about non-design thermal movements of steam pipelines.

The control of thermal displacements of steam pipelines at thermal power plants is carried out mechanically, which does not provide prompt information acquisition in the “On-Line” mode for quality control and monitoring. Steam temperature changes in steam lines cause changes in their linear dimensions, as a result of which compensation stresses arise in steam lines.

Any kind of pinching caused by a malfunction of the supports or by restriction of movement by equipment or building structures located nearby can lead to a sharp increase in the level of compensation stresses and thereby reduce the reliability of the steam pipeline.

A means of observing the thermal displacements of steam pipelines are special indicators (benchmarks), which must be installed on all straight sections of these steam pipelines at a distance of at least 100 mm from the bend or welded joint and at least 200 mm from the edge of the support.

All steam pipelines with an inner diameter of 150 mm and more and a steam temperature of 300 ° C and above are subject to control over thermal displacements [1]

1.Indicators of thermal displacements of steam pipelines (benchmarks).Fig . 1

Fig . 1. Mechanical indicator of thermal displacement of steam lines

Readings from mechanical indicators are taken when the steam pipeline reaches the design parameters. On paper or plates, the points of contact of the leads or the tips of the rods are marked crosswise, corresponding to the operating state of the steam lines. The readings of the plates are transferred to tracing paper. The scale bar measures the projections of the obtained curves on each axis. The measurement results for each indicator are recorded in the forms.

The measured values of displacements are compared with the calculated (design) ones. Then the plates are repainted or new sheets of paper are installed, after which all three fixed points are applied. Mechanical pointers (indicators) of the thermal displacement of steam pipelines, the existing control of the displacements of steam pipelines at thermal power plants is carried out mechanically, which does not provide prompt receipt of information in the "On-Line" mode.

1.1 Installation of indicators of thermal displacement on the steam line. (Fig . 2)

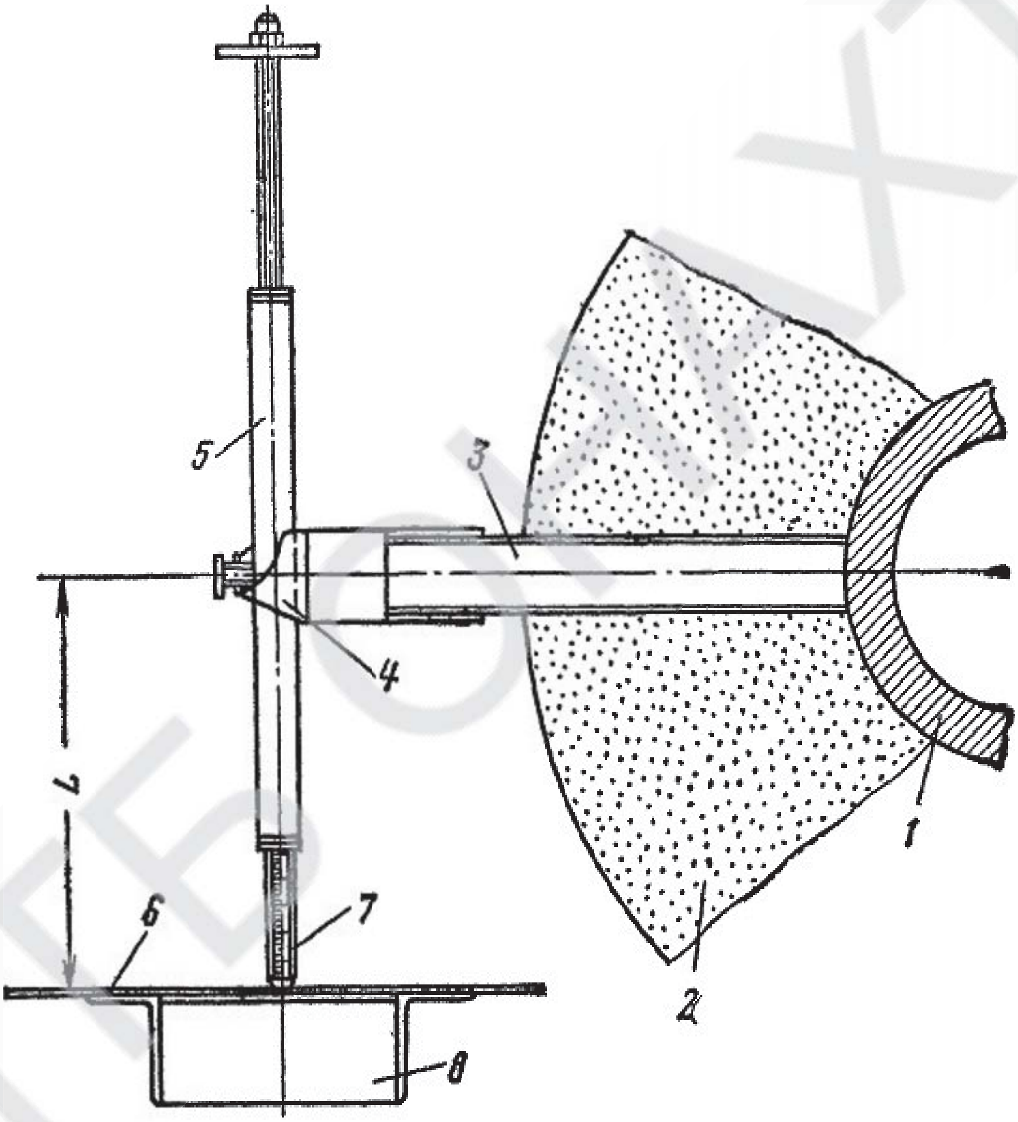

Fig . 2. Installation of thermal displacement sensors on the steam line.

Installation of sensors on the steam line: 1 - steam line; 2 - thermal insulation; 3 - bracket; 4 - indicator housing assembly; 5 - stock; 6 - plate; 7 - rod; 8 - removable head.

The purpose of control over the thermal displacements of steam pipelines is:

- assessment of compliance of actual thermal displacements of steam pipelines with design ones;

- prevention and timely detection of pinching of steam lines;
- assessment of the serviceability of the steam pipe fastening system;
- detection of violations of the operating modes of steam pipelines due to violations of the heating and cooling modes (deformation of the steam pipe axis, hydraulic shocks).

A means of control of the displacements of steam pipelines is a movement indicator that allows you to register and measure the spatial displacements of the steam pipeline relative to fixed structures.

The development of control schemes for thermal displacements with the determination of the installation locations of the indicators is carried out by the design organization when designing steam pipelines. The control over displacements of steam pipelines in operation that have not been organized, these schemes are carried out by the personnel of the TPP and are coordinated with the design or with a specialized commissioning contractor.

Covered by the project the indicator design should provide the ability to register the visible thermal displacements of steam pipelines, i.e. displacements during heating from a cold state to a working one and during cooling. It is allowed to use an indicator to control total thermal displacements, i.e. displacements from the installation state to the working one.

The design should indicate the dimensions of the gaps in the working and cold states of the steam pipeline in the places where the steam pipeline passes through the ceilings, service platforms, building structures, taking into account the thickness of the thermal insulation and thermal displacements of the steam pipelines.

The project should provide the sites for servicing the indicators.

The indicators are installed on straight sections of steam pipelines, preferably near the bends through 2-3 inter-support spans in places with the expected maximum values of thermal displacements and convenient for access and maintenance.

At least three indicators should be provided on the steam pipelines from the boiler to the turbine of block plants, on power plants with cross-links - at least two indicators on the steam pipelines from the boiler to the switching header and from the switching header to the turbine.

In order to detect deformation of the steam pipeline due to temperature irregularities, it is advisable to install two indicators at the ends of the section and one in the middle of the section on horizontal sections longer than 5 m.

It is not recommended to install the indicator near fixed supports of the steam line.

The installation of indicators should be carried out in the following sequence:
- welding the bracket to the steam line before applying thermal insulation;
- installation of rods in the bracket, installation of the corner frame and its welding to fixed structures after applying thermal insulation and cutting off the blocking ties of the supports springs.

In the case when the measurement limits of the indicator exceed the maximum design values of the total displacements of the steam line, it is allowed to install the corner frames of the indicator before cutting off the blocking ties of the support springs, while controlling the complete displacements of the steam line. At the same time, in order to avoid damage during installation and insulation work, after fixing the position indicators of the steam line axis on the plates (the springs of the supports are interlocked with welded ties), the rods should be removed and reinstalled after all installation and insulation works are completed before the steam pipeline warms up.

The indicator bracket is welded to the steam line at a distance of at least 100 mm from the bend, welded joint and at least 200 mm from the edge of the support. In this case, the indicator rods should be directed along the coordinate axes adopted in the design calculations.

In order for both indicator plates to be in a vertical plane (in this case, the cleanliness of the working surfaces of the plates under operating conditions is ensured), it is recommended to place the bracket welded to the steam line vertically. In cases where this is impossible due to the layout conditions or when installing the indicator on vertical sections of steam pipelines, it is allowed to cut the bracket and weld its head to fix the rods at an angle of 90 °. It should be provided that the distance L1 from the head of the bracket to the surface of the thermal insulation is greater than the length of the indicator rod. This ensures the possibility of replacing the rods in case of damage during operation.

The existing control of the displacement of steam pipelines at thermal power plants is carried out mechanically, which does not provide prompt information acquisition in the "On-Line" mode for quality control and monitoring.

During the operation of the power unit at thermal power plants, the displacement of steam pipelines may be affected by loads that are not provided for in the design. These loads, first of all, include non-design movement of equipment, coolant in all operating modes. To obtain reliable results on operational loads, it is necessary to identify all possible loading factors and develop methods for their determination based on the readings of thermal displacement sensors of steam pipelines.

To measure thermal displacements of steam pipelines, manufacturers produce sensors with analog and digital outputs, as well as ultrasonic sensors. After connecting the sensors of thermal displacements of steam pipelines to the controller, the system for monitoring thermal displacements of steam pipelines operates according to the working software of the PTC (software and hardware complex).

1. A step-by-step algorithm for outputting these signals from thermal displacement sensors of steam pipelines with analog outputs in the APCS:

This scientific paper describes the conversion into a digital system of signals from sensors of thermal displacement of steam pipelines with analog outputs in the process control system.

Further the scientific paper describes and gives the references to the conversion algorithm of existing mechanical systems into digital ones of.

Algorithm for transferring existing mechanical systems for controlling thermal movements of steam pipelines into a digital APCS system:

1.1 Purchase a displacement sensor with a free stem (with no guides, the stem moves freely) with an analog output 4-20Ma from the manufacturer's plant

(Germany, Japan, Russia, etc.) Or order for each steam line individually according to the technical requirement;

Displacement sensor with analog output of the DCTH series (LVDT). (Fig . 3)

The DCTH series displacement sensor is designed for accurate displacement measurements. It has a built-in preamplifier and allows you to receive an analog voltage or current signal at the output.

Versions available: free stem, spring return, guided, high resolution / precision; great resource; stainless steel.

DCTH series with free stem. Free stem sensors have no guides. The stem moves freely.

It is recommended to take the following designation and direction of the axes of the coordinate system (parameters are measured in 3 or three coordinate axes):

X1 - along the main building towards the temporary end;

X2 - at an angle of 90 ° to the axis of the main building;

X3 - vertically [2].

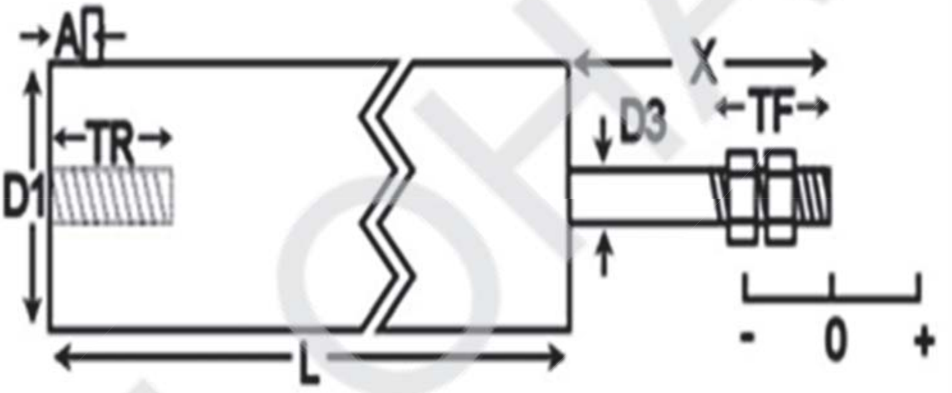

Fig . 3. DCTH Series sensor with Free Stem

1.2 Install the displacement sensor to the steam line, in accordance with the technical requirements, similar to the installation of indicators of thermal displacement on the steam line (see Fig . 3 Installation of indicators of thermal displacement on the steam line).

1.2.1 Connect the ~ 220V power supply to the sensor and the 4-20mA output to the ADC module; (Fig . 5)

Output signals from steam pipe thermal displacement sensors with 4-20mA output analog signals or digital signals can be connected directly to the PLC, sensors with analog output through analog-digital modules, sensors with digital output through digital modules, where signals are processed.

2. Connect the displacement sensor to the analog module, which serves to filter signals and convert the analog signal into digital one. (Fig . 4)

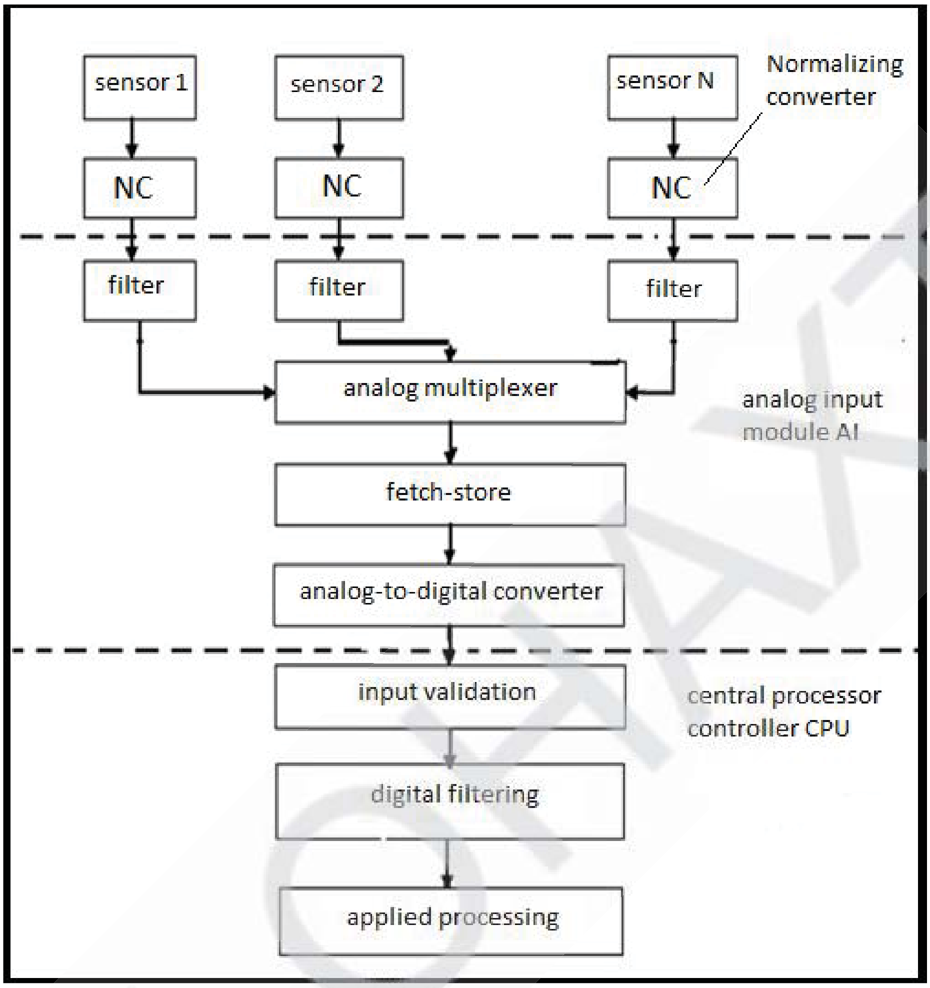

Fig . 4. chart of processing an analog signal when entering the controller

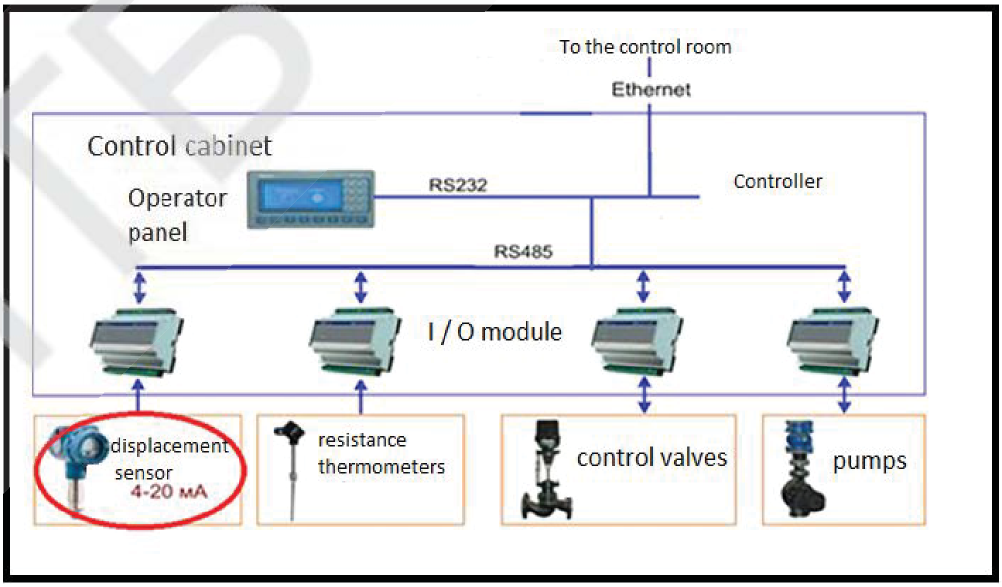

Fig . 5. Connecting analog sensors to the APCS system

3. Use of the station of the distributed periphery for sensors of thermal displacement of steam lines and connection to controllers.

If the sensor is located at a long distance from the controller, then a distributed periphery station is installed close to the displacement sensors;

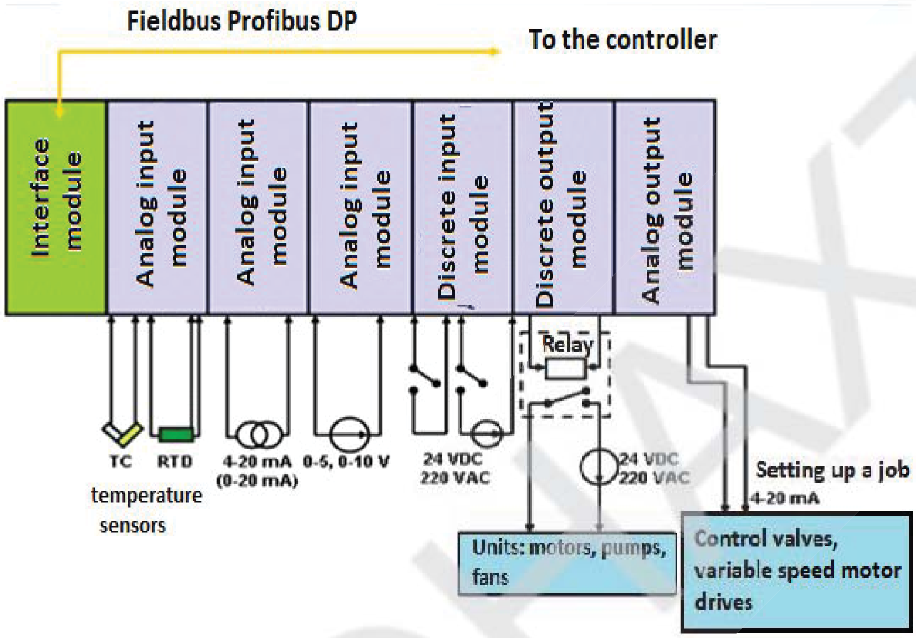

Fig . 6. Input / Output chart using a distributed periphery station

More rational in this situation is the use of distributed periphery stations located in close proximity to the sensors of thermal displacement of steam pipelines. (Fig . 6) These stations contain the necessary input and output modules as well as interface modules for connecting to the PLC via a digital fieldbus (for example, using the Profibus DP protocol, or Modbus RTU).

All signals are digitally transmitted over a single cable with a high level of noise immunity. The so-called intelligent sensors and actuators (which include controllers and other units that convert the signal into digital form and implement data exchange through the field bus) can also be directly connected to the field bus.

5. Loading the analog module to the controller;

Load the analog module to the APCS controller, after completing 8 points of loading the sensor to the module, the controller receives all messages from the sensor. (Fig . 7)

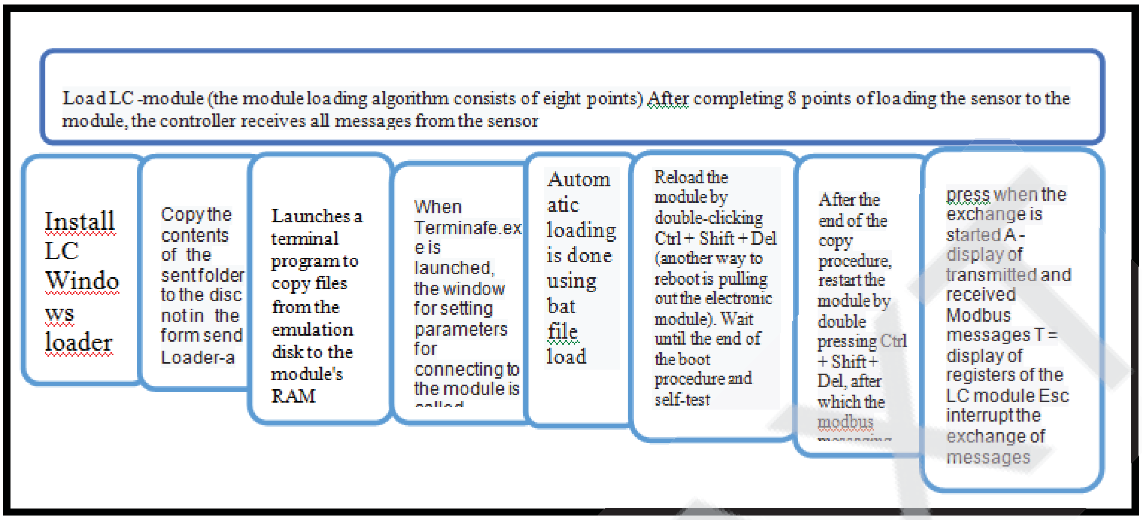

Fig . 7. Loading the analog module to the controller

6. Algorithm for creating a point in the system of global databases of APCS

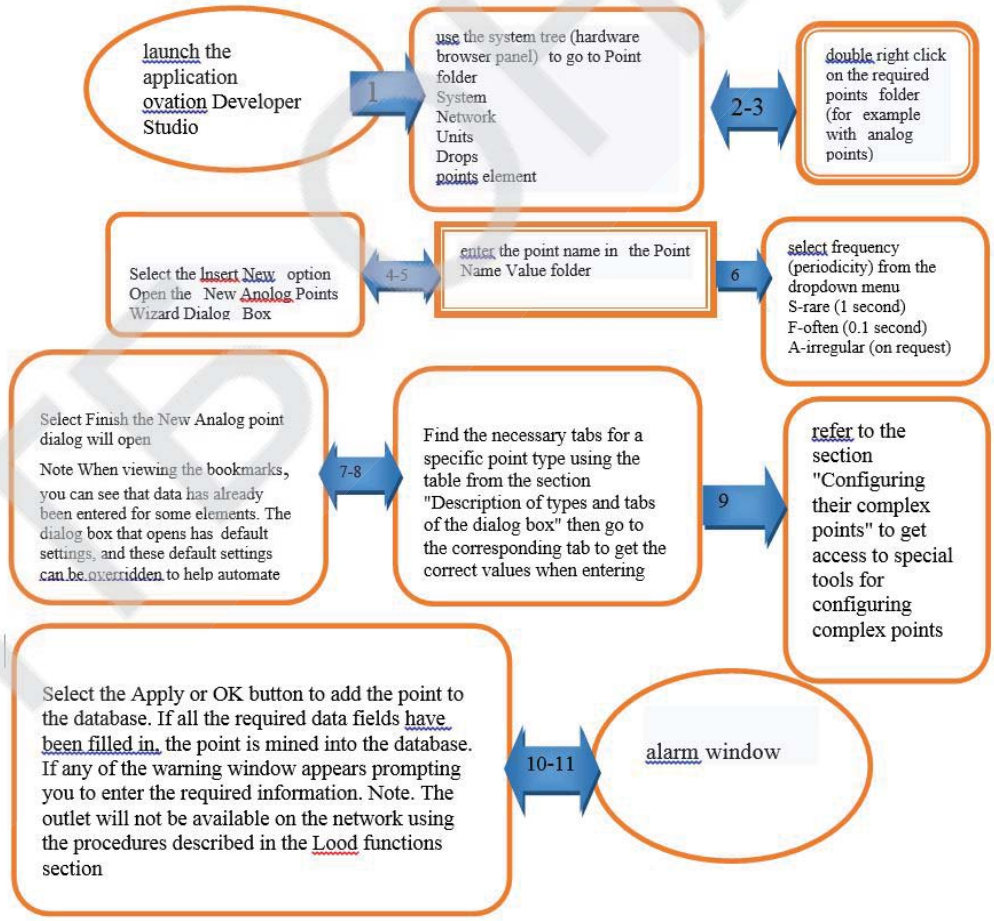

Fig . 8. Creation of a point in the system of global databases of the PTC APCS.

After loading the analog module to the controller, a point is created in the global PTC database. A point is a record in the global database that contains a value (for example, an input or output signal) and other related data.

At the moment, there are 11 types of points in the APCS system. (Fig . 8). Each point type has its own dialog box with separate tabs and fields.

After connecting the sensor to the module, loading the module to the controller and creating a point in the PTC database. The control system of the thermal displacements of steam pipelines is integrated with the APCS system.

The control system of the thermal displacements of steam pipelines operates according to the operating software of the PTC APCS. To identify non-design thermal displacements of steam pipelines in the "On-line" mode in all operating modes and take into account their real displacements; Timely identify zones of occurrence of thermal displacements and promptly signal operating personnel about non-design thermal displacements: Alarm triggering with output: - to light signaling (board); - for warning signaling; - for emergency signaling.

Simultaneously in real time (On-Line) measurement of the current values of the displacements of steam pipelines, accumulates and stores the values of the measured values, and presents the measured value in the form of tables, graphs, including archived changes [3]

V. Conclusion

The research subject of scientific paper is:

- Conversion of a functioning mechanical control system for thermal displacements of steam pipelines into a digital control and monitoring system of technological parameters of the tested object, in real time using the software of the PTC APCS.

According to the results of the study, it can be concluded that an "Algorithm with the output of data from displacement sensors to the PTC of APCS" has been developed.

The control system of the thermal displacements of steam pipelines is integrated into the APCS system and operates according to the operating software of the APCS.

The task of the scientific paper is to output the signals from the sensors of thermal displacement of steam pipelines to the APCS.

The object and subject of study is the connection of sensors of thermal displacement of steam pipelines with analog and digital outputs to the PTC controller of the APCS.

The proposed algorithm will allow adding signals from displacement sensors to the PTC of the APCS.

With a significant territorial length of cable lines from each displacement sensor, it is proposed to use a distributed periphery station to connect the PTC sensors of the APCS.

PTC APCS monitors the control system of thermal displacement of steam pipelines:

- The value of the thermal displacement of the steam pipelines in the specified coordinates.
- Comparison of the values of the displacements of the steam lines with previous measurements.
- Determination of the actual measurement parameters of steam lines - the rate of change and the metal temperature value change at the point of displacement control.

The achieved results of the scientific paper can be recommended for use in the control system of thermal displacements of steam pipelines with the output of data from displacement sensors to the automated process control system PTC "Ovation".

An algorithm for inputting data from the sensors of the control system of the thermal movements of steam pipelines in the automated process control system of the PTC "Ovation" has been developed:

An algorithm for loading (eight items) of an analog module into the Ovation controller has been proposed.

- An algorithm for creating a point in the system, the global database of the APCS PTC "Ovation" with illustrations of dialog boxes, which consists of 11 points, is proposed.

VI. References:

1. RD 34.39.301-87 Guidelines for control of thermal displacements of steam pipelines at thermal power plants,http://www.conatem.ru/tehnologiya_metallov/teplovoe-rasshirenie-metalla.html
2. http://www.ndt-td.ru/katalog/tenzometricheskoe-oborudovanie/tenzometricheskie-datchiki/datchiki-peremescheniya/induktivnie-datchiki-peremescheniya-lvdt/datchik-peremescheniya-s-analogovim-vihodom-serii-dcth-lvdt.html
3. Kuznetsov A. PTC "Ovation" modernizes power plants http://www.energoportal.ru/ptk-ovation-moderniziruet,
http://www.emersonprocess.com

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The collection includes student works of the participants of the competition, which were not included in the number of prize-winners. The texts of the competitive works are published in the form in which they were submitted by the authors. The authors of the articles are responsible for the content and form of submission of the material.

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