

Algorithm and Software Implementation of the Diagnostic System for the Technical Condition of Powerful Units

Olimjon Toirov^{1,2*}, and *Salikhdjan Khalikov*³

¹Department of Electrical Machines, Tashkent State Technical University, 100095 Tashkent, Uzbekistan

²Institute of Energy Problems, Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan

³Department of Electromechanics and Electrotechnology, Tashkent State Technical University, Tashkent, Uzbekistan

Abstract. This article discusses the software implementation of the diagnostic system for auxiliary equipment of power plants (on the example of smoke exhausters). The developed program of diagnostics of auxiliary equipment of electric power plants is given on the example of condition diagnostics designed for early detection and localization of certain defects and providing recommendations for their elimination in smoke pumps, which should ensure the issuance of appropriate protocols and, upon request, protocols of the current state of smoke pumps, quality assessment of repairs and special tests, as well as graphs of retrospective parameter values for the time period selected by the user, where the users of the task - there are heads and deputy heads of workshops, senior foremen, repair engineers, as well as specialists of the planning and technical department. The problem is considered, which was solved within the framework of the software and hardware complex of the automated process control system) of the 800 MW power unit No.1 of Talimarjan TPP and is intended for operational specialists, where the task operates under the Windows operating system and the program is written in the C++ programming language Builder 6 for the development of application tasks with client-server architecture. And also the composition of the program and the program menu are given: "Task Launch", "Daily statements", "Input data", "Output forms", "Diagnostics" and "Special tests" allow you to implement the required task function at the moment. In addition, the article presents elements and components, processes and conditions of a pumping plant, pumping station and pumping station cascade, potentially dangerous and processes and conditions potentially dangerous for a pumping plant, pumping station and pumping station cascade.

1. Introduction

Currently, diagnostics of the technical condition of the equipment of electric and pumping stations is one of the urgent tasks of improving the reliability of their operation, as well as optimal planning for the repair of the main and auxiliary equipment [1, 2, 3, 4].

One of the components of improving the reliability of the operation of power plants is a system for diagnosing the technical condition of powerful units and their auxiliary equipment [5, 6].

The current state of long-term operated plants requires the use of such diagnostic systems that would make it possible to detect malfunctions in the normal operation of the equipment. This will not only prevent an emergency failure of the equipment, but also ensure optimal planning for the withdrawal of the main and auxiliary equipment of the power plant for repair [7,8].

The developed program for diagnosing auxiliary equipment of power plants on the example of condition diagnostics is intended for early detection and localization of certain defects and providing recommendations for their elimination in smoke exhausters. The program must provide the issuance of the appropriate protocols. Upon request, protocols of the current state of smoke exhausters, assessment of the quality of repairs and special tests, as well as graphs of retrospective parameter values for a period of time selected by the user [9,10] should be obtained.

Diagnostics of the technical condition of both the main and auxiliary power equipment of power plants, which include vertical pumps, smoke pumps, blow fans, cooling systems, etc., assumes both the availability of modern technical means of measuring and monitoring the current state of the unit and computer equipment (SVT), and the development of operational diagnostic algorithms and their software implementation [11, 12, 13].

*Corresponding author: olimjontoirov@gmail.com

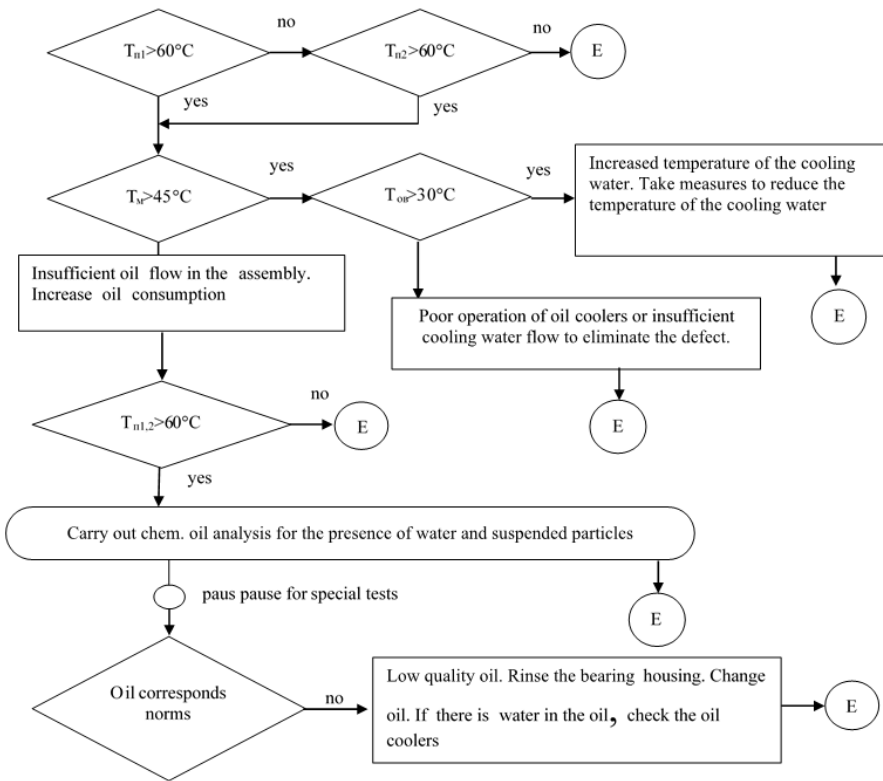


Fig. 1. Fragment of the diagnostic algorithm

Currently, the software and hardware complex (PTK) of the automated process control system (Automated process control System) of unit No. 1 of the Talimarjan TPP has been developed and is functioning. During the design, the PTC also included a subsystem for diagnostics of elements of the main (steam boiler, turbine and generator) and auxiliary equipment of the station (generator cooling and ventilation systems, traction mechanisms and vertical pumps, smoke pumps).

Diagnostics of auxiliary equipment in the proposed concept involves the identification of malfunctions as a result of processing operational sensor readings of the standard monitoring system, as well as readings entered manually once a day and processing data based on the results of special tests. The conclusion about the presence of a malfunction is made according to decision-making algorithms with recommendations on further actions of the operational personnel of the station in case of identified defects.

The diagnostic algorithms are constructed in the form of a stepwise logical structure, at the first stage of which the parameters deviated from the normative or reference values, which are commonly called diagnostic signs, are revealed. Based on the analysis of several (or one) diagnostic signs and, if necessary, some additional conditions, logical decision-making chains such as rules (products) "if ... then ..." are formed. The issuance of messages to operational personnel about suspected malfunctions is accompanied by a list of measures that can ensure their search and elimination.

A fragment of the diagnostic algorithm is shown in Figure 1.

The result of the task of diagnosing any equipment, and, in particular, vertical pumps, at a thermal power plant is the issuance of not only diagnostic messages on the screen and printing for the operating personnel of the station, but also the corresponding regulated documents. Such documents are:

1. Status assessment protocol.
2. Report of special tests.
3. Protocol for assessing the quality of repairs.

4. Graph of parameter values.
5. Protocol of retrospective values of parameters.

The program should ensure the issuance of appropriate protocols. Upon request, protocols of the current state of the smoke pumps, quality assessments of repairs and special tests, as well as graphs of retrospective parameter values for the time period selected by the user should be obtained [1-16].

2. Materials and Methods

The diagnostic program is based on the main nodes, the condition of which affects the performance of the unit. Starting the task, entering information, viewing and printing the results takes place in the dialog mode.

The task was solved within the framework of the software and hardware complex (PTC) of the automated process control system (Automated process control system) of the 800 MW power unit No. 1 of the Talimarjan TPP and is intended for operational specialists. The users of the task are the heads and deputy heads of workshops, senior foremen, repair engineers, as well as specialists of the planning and technical department (PTO).

The task operates under the Windows 2000 operating system. The program is written in the C++ Builder 6 programming language for the development of application tasks with client-server architecture. The task is designed as a multi-document application and is based on the main concepts of C++ Builder 6, i.e. it uses the concepts of forms, component models and event handling [14-16].

The program includes:

files containing normative reference information (NSI);

files containing a list of input parameters entered automatically from the automated process control system database and entered manually into the daily statement and special service files necessary for the operation of the program. The task works in real time and the task has a modular structure. Each module provides the implementation of some function. The most important of them are: checking the input data for reliability, forming various archive files, forming blank output forms (protocols) (file DMV.cpp , Data.cpp , HandIsp.cpp); diagnostic procedure for the current day of operation of the smoke pump and after special tests (Diagn.cpp, Diagspecial.cpp); entering the necessary information and diagnostic messages into the daily protocols.

The connection with the instant database is established automatically once after the program is started. Communication is established using a specially developed driver, which is based on OLE for Process Control technology, which is the main standard for interaction between software components of modern data acquisition and control systems (SCADA). The OPC client program allows you to interrogate the necessary sensors in real time at a given interval.

In one cycle of questioning of sensors of regular control, information is entered immediately for all controlled parameters. The time interval between cycles is set to 1 minute. The polling cycle can be adjusted programmatically using the Timer component. The time interval between timer events is set in milliseconds as the value of the "Interval" property. After the time intervals specified in the "Interval" property, the Timer component generates the OnTimer event.

The structure of the input information for each of the parameters is as follows:

parameter code (symbolic information);

the current value of the parameter (real value);

a sign of confidence (integer value).

Reading of parameter values from the Database of the PTK automated Process Control System is carried out by the identifier of the parameter code, with a preliminary analysis of sensor readings for reliability. The current value for each of the parameters is compared with the value of the corresponding bid specified in the NSI or the list of input parameters of the task. If the ACS codes of the list of input parameters do not match the codes in the task database, a message is sent to the user about the impossibility of reading the parameter and the task stops working. If the ACS codes match, the task continues to function, thus the reading of the undiscovered parameter is excluded.

3. Results and Discussion

The problem uses both automatically entered analog and discrete parameters, as well as experimentally obtained parameters. The calculations use only the data averaged over the course of each mode.

Figure 2 shows the main task menu, consisting of many components representing a multi-page menu.

The so-called windows in the program menu: - "task launch", "daily statements", "input data", "output forms", "diagnostics" and "special tests" allow you to implement the task function required at the moment.

Without interrupting the main work of the task – reading automatically entered data, you can perform the following actions:

viewing and printing all types of statements (protocols);

adjustment of the nsi.

After launching the program, a form appears on the screen that includes a menu for the user from which you can select the desired position:

- running a task in real time or when running control examples testing the program;
- manual input of experimental data obtained during special tests of smoke pumps;
- working with reference books;
- filling in daily statements manually and automatically;
- starting a diagnostic task;
- obtaining the necessary output forms (protocols);
- viewing graphical dependencies.

The mode of operation of the program is continuous, in real time.

The means of controlling the correctness of the task are control examples, launched, if necessary, by a specialist servicing the software for the task of diagnosing auxiliary equipment of the power unit, which is provided in the program menu (see Fig.1.).

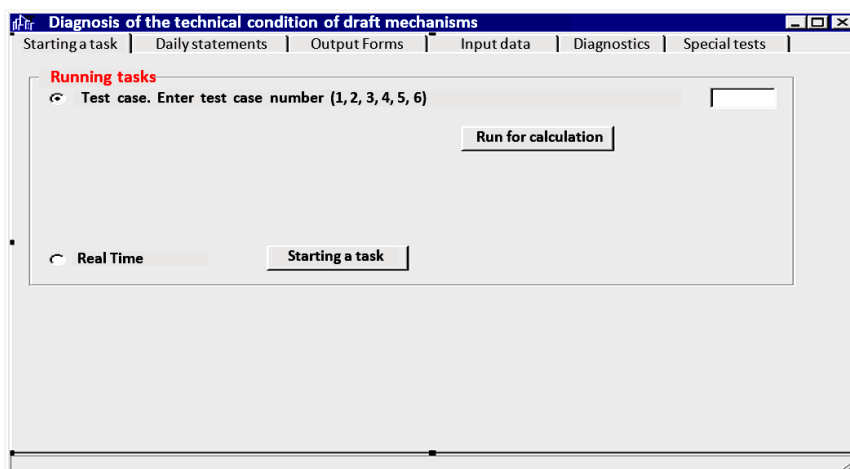


Fig. 2. Program menu. Launching the program

The Task Launch page provides for launching the task in real time, as well as entering control examples to verify the correct functioning of the task. In both cases, on the panel at the bottom of the window, in the status bar (StatusBar component), designed to display auxiliary information, the message "Regular monitoring sensors are being interrogated" will appear. The procedure for questioning the sensors of the standard control is implemented in the program by the VvodASU function. Verification of the reliability of each sensor reading is carried out by the Authentic procedure [14]. The survey of sensors is set by a timer - the Timer component, the discreteness of information retrieval is set in the properties of this component in milliseconds.

When checking the correct functioning of the program, the survey of sensors in the control example, the number of which is dialed from the menu, continues until automatic data entry from the task database is simulated. The number of time points in all control examples is set to 12, but this value can be increased and is limited only for reasons of the speed of the test run. When running the control examples, a message will appear on the screen to the user: "Input values of input parameters from the control example are being entered. Wait.". At the end of entering the control example, a message will appear: "The data entry of the control example is finished".

Page "daily statements". the program provides for automatic filling of daily archive files containing readings of sensors of regular monitoring, recorded every minute (i.e. 1440 time points). The storage of this type of information is necessary for technologists for further retrospective analysis. each such archive file has a name containing a specific abbreviation and the date of data removal. For example, the name of such a file stored in the archive for smoke pumps A and B has the form "07sa(b)250606.dbf", where "07" is the cipher of the task, "S" is daily, "AB" is for smoke pumps A or B, "250606" is the date of file creation (25.06.06). Also, at the beginning of each day, empty archive daily files of the form "07hsa.dbf" and "07hsb.dbf" are formed, which are filled in after each day.

The "Input information" page. Input information is presented in the form of a list of automatically entered parameters from the automated process control system database - the Nsi1.dbf data file and a list of manual measurements - the Nsi2.dbf file. Both lists are viewed from the menu on the "Input data" page (Fig.2). The program allows you to view and adjust the lists of input information.

The input of experimental data in the statements of special (SpesIspA.dbf, SpesIspB.dbf) tests of smoke pumps A or B is carried out by password. The password is entered from the screen, the password is typed in the window of the DBEdit component, only with a certain set of letters (or numbers) the corresponding sheet opens, in which new data must be entered. If no experiments were carried out at the time of filling out the statement, the experimental data is automatically overwritten, only the date is updated.

At the end of the day, empty forms are formed – protocols for assessing the quality of repairs and protocols for special tests of smoke pumps. They are necessary for the operational personnel - users of the task for their further filling. These are files like "ProtEstA250606.dbf" and "ProtSpecIspA250606.dbf".

The mode of formation of the daily statement. To work with the daily statement, the "Daily statements" page of the program menu is provided (Figure 3).

The statement will open on the screen in the form of a table containing the names of parameters entered manually from the screen, their program designation and empty columns where measurements should be recorded every two hours. In the process of filling in, for the convenience of the user, the name of this parameter is present under the table, the values of which are entered from the screen. After the manual measurements are completed, the latter are programmatically checked for reliability by comparing the current value with the smallest and largest permissible parameter values. This procedure is implemented by the Hand Input function. If the input is successful, a message appears on the screen "No errors were detected when entering", if the parameter values are entered incorrectly, a message appears "An error was detected when entering. Check the parameter (its name and the hour of measurement are given)." After closing the statement filled in manually, the message "After manual input, enter the automated control system data" will appear.

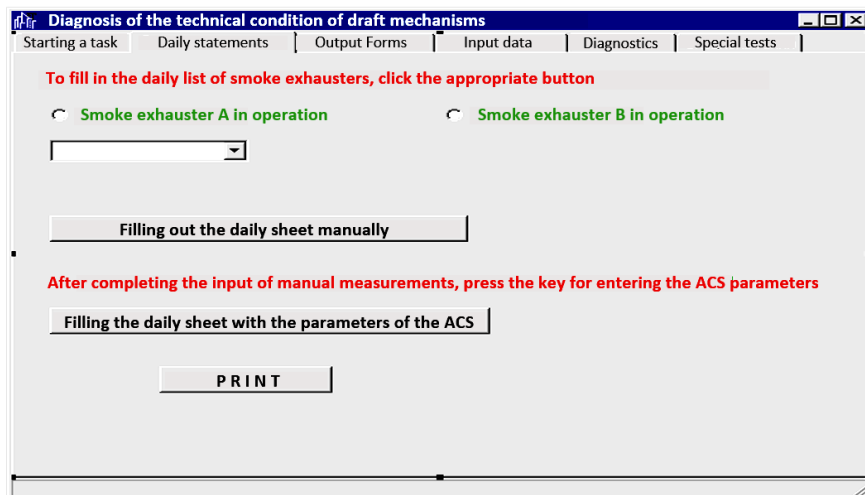


Fig. 3. Program menu. Filling in the daily statements

The program automatically enters the readings averaged during the observation of the sensors of the regular control by pressing "Automatic entry into the daily list of parameters of the automated control system". This opens the daily statement, already filled with data. After closing the statement, a message will appear: "After completing the daily statement, run DIAGNOSTICS" (Figure 4).

The program provides for printing daily statements of smoke pumps through the main menu of the program (the "Print" key).

Diagnostic mode. Technological algorithms for the diagnosis of smoke pumps assume that the diagnosis is based on reliable data contained in the daily statements. Diagnostic algorithms assume the processing of information every day, as well as after special tests. If malfunctions are detected or the diagnosis needs to be clarified as a result of special tests, messages appear on the screen to the user. All diagnostic messages and recommendations are

automatically recorded in the diagnostic message logs for each smoke pump in the data file - MessageA(B).dbf and in the corresponding status assessment protocols.
The software implementation of technological diagnostic algorithms involves a minimum of actions on the part of the user.

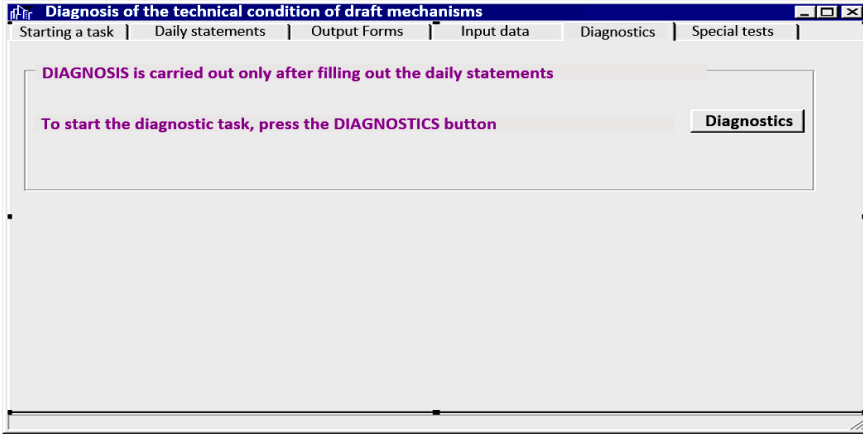


Fig. 4. Program menu: Diagnostics

A daily review of the proto (Figure 5) cols for assessing the condition of each smoke pump will reveal the need for certain special tests. For this purpose, the so-called route maps are provided for specialists conducting tests. As a result of the tests, certain malfunctions are identified, the numbers of which must be entered in the protocols and logs of malfunctions. To do this, the "Special Tests" page is provided in the program menu, programmatically this procedure is implemented in a file Diagspecial.cpp .

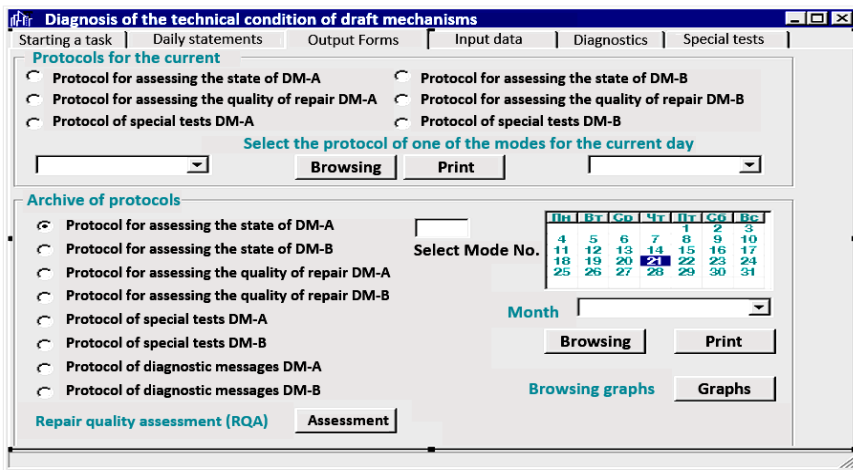


Fig. 5. Program menu. Output forms of the task

Through the program menu), it is enough to enter an integer (identifier) corresponding to the number of the diagnostic message. A list of all possible malfunctions of smoke pumps and their numbers (identifiers) are given in a special directory of diagnostic messages on the "Input parameters" page of the program menu.
Output forms and graphs. For the organization of long-term storage and the possibility of retrospective analysis, both current and archived output forms of the state of the smoke pumps are created in the program. The interface for using output forms (protocols) provides for viewing, printing and graphical interpretation of data files. The call of all

necessary procedures is programmatically implemented from the main form and is presented on the "Output Forms" page of the program menu.

The output forms page consists of two main parts – the menu of protocols prepared on the basis of the current daily statement, and the menu of archive files stored in a subdirectory of the hard disk.

To view the current protocols, a list is organized containing status assessment protocols, the number of which corresponds to the number of operating modes of the smoke pump over the past day.

The calendar component is used to view archived protocols.

The task provides a procedure for assessing the quality of the repair carried out, which is implemented using the Estimation (int X) software function, as well as the ability to view in graphical form a retrospective of changes in the fixed parameters of the smoke pumps.

The charting program has been developed as a separate application "PrGrath.exe" and is called using the WinExec WindowsAPI function ("PrGrath.exe", SW_SHOWMINIMIZED).

To test the program, control examples are provided, which are entered at startup. At the same time, not a driver is started that connects the program to a common database, but a simulation of reading sensor readings is performed in the form of accessing the data table - the Primer.dbf file, reading the necessary parameters from it for a fixed period of time. The following actions are similar to the actions typical for the task operation mode and described above.

At the stage of implementation of the task, it is necessary to adjust the normative reference information, diagnostic messages and control examples.

Input and output data. All program files containing permanent service information, input and output data are created in dBase IV relational tables format. The information base of the described project consists of files with the .dbf extension located in a certain directory, some of which contain input information for the program, and some of which contain output information.

Data files. As a rule, these files contain normative reference information, a list of diagnostic messages, a list of input parameters entered automatically and manually, experimental data files.

Output data files. In the program, the files SutVed, SutVedA, SutVedB SutReg are daily output files that store the current readings of the sensors of the standard control and manual measurements. In the course of the program, archived output files of the form ProtokolStA ProtokolStB – protocols for assessing the condition of smoke pumps, ProtokolIspitA, ProtokolIspitB -protocols of special tests are created.

All messages that occur both during loading and analysis, and during diagnosis, are displayed on the display screen, in the course of their occurrence.

According to the same principle, diagnostic programs have been developed for the rest of the auxiliary equipment of the Talimarjan TPP Unit No. 1.

4. Conclusions

- a) The developed diagnostic system program allows you to identify malfunctions in the normal operation of the equipment. This will not only prevent an emergency equipment failure, but also ensure optimal planning for the repair of the main and auxiliary equipment of the power plant.
- b) The developed program for diagnosing auxiliary equipment of electric power plants on the example of condition diagnostics allows early detection and localization of certain defects and providing recommendations for their elimination in smoke pumps
- c) One of the advantages of the diagnostic systems being developed is that they can be implemented not only for auxiliary equipment at stations under construction and in operation, but also at other similar facilities, provided they are equipped with computer equipment with some software adjustments.
- d) The developed diagnostic programs can be used to create a database of violations in the reliability analysis and safety assessment of the main and auxiliary equipment of the power plant.
- e) The developed diagnostic system is economically feasible from the point of view of timely detection of malfunctions on operating equipment and prevention of emergency shutdowns, and can also be implemented not only at plants under construction, but also at existing plants, when they are modernized and equipped with automated process control systems.

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