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APPLICATION FOR VIBRATION DIAGNOSTICS

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Abstract. *This paper considers the issue of developing an application for vibration diagnostics of bearings of functional pairs of critical structures, this application should help in monitoring and diagnosing bearings, using vibration signals, without disassembling the functional unit itself. It is known that vibration diagnostics is effective and there is a tendency to reduce the cost of its implementation. Monitoring and diagnostics based on vibration parameters can be applied at any time, even after several years of equipment operation, when the costs of preventive maintenance and repair will exceed the economically justified value. Also, in the work, the basics of the subject area for the development of mobile applications are considered, and a review of existing solutions is made. Requirements for the application for performing vibration diagnostics are formulated. The architecture is designed and the data description for the application of vibration diagnostics is carried out.*

Keywords: vibration diagnostic, application, bearing, vibration signal

APLIKACJA DO DIAGNOSTYKI WIBRACYJNEJ

Streszczenie. *W artykule poruszono problematykę opracowania aplikacji do diagnostyki wibracyjnej łożysk par funkcjonalnych konstrukcji krytycznych, która to aplikacja powinna pomóc w monitorowaniu i diagnozowaniu łożysk z wykorzystaniem sygnałów wibracyjnych, bez demontażu samego zespołu funkcjonalnego. Wiadomo, że diagnostyka wibracyjna jest skuteczna i istnieje tendencja do obniżania kosztów jej wykonania. Monitoring i diagnostyka na podstawie parametrów drgań może być stosowana w dowolnym momencie, nawet po kilku latach eksploatacji urządzeń, gdy koszty obsługi prewencyjnej i napraw przekroczą ekonomicznie uzasadnioną wartość. W pracy rozważane są również podstawy tematyki tworzenia aplikacji mobilnych oraz dokonywany jest przegląd istniejących rozwiązań. Sformułowano wymagania dla aplikacji do wykonywania diagnostyki wibracyjnej. Zaprojektowano architekturę i wykonano opis danych dla aplikacji diagnostyki wibracyjnej.*

Słowa kluczowe: diagnostyka wibracyjna, aplikacja, łożysko, sygnał wibracyjny

Introduction

At the present stage of development in production, a continuous technological process is very important, which is ensured by the trouble-free operation of the equipment. This requires a constant increase in the requirements for the accuracy of measuring control points of equipment and methods of technical control, as part of technological processes. Therefore, one of the urgent tasks is to conduct vibration control.

Increased vibration in machines can cause serious damage. Stresses caused by vibration contribute to the accumulation of damage in materials, cracks and damage. Such problems can be detected at the beginning using vibration measurement methods. Thus, there is a great need to measure, evaluate and control the vibration of industrial equipment.

Thus, improving the technical level, quality, and reliability of machines, and improving their use largely depends on the technical diagnostics used [6, 11]. Continuous diagnostics or vibration monitoring is used for critical units or expensive machines. Monitoring provides continuous monitoring of the condition of the machine and alarm in case exceeding the maximum permissible vibration level. Continuous vibration testing allows [9]:

1) To build a graph of the vibration level change depending on the operating time.
2) To predict the unit's residual operating time before scheduled repairs.
3) To avoid damage to the unit due to a sharp increase in vibration.

Periodic vibration diagnostics is used to diagnose machines that do not require continuous vibration monitoring. Periodic vibration diagnostics allows [5]:

1) To identify the causes of increased vibration, when vibration becomes perceptible, but has not yet led to a breakdown of the mechanism.
2) To assess the compliance of the vibration level with the established standards.
3) To determine the possibility of further operation or methods of modernization of "problem" units.

Diagnostic methods are based on the analysis of vibration generated in rolling bearings by frictional forces [5]. One of the methods for searching for defects that have found wide application is frequency (spectral) analysis of vibration [6], which allows it to be divided into components of different frequencies, excited by different sources of vibration forces and having different natures and different properties.

The presence of a defect in the rolling bearing during their rotation leads to the appearance of intense spectral components in the vibration signal [10], the position of which on the frequency axis depends on the location of the defect, the rotation speed, and the geometric dimensions of the diagnosed nodes. The amplitude of these spectral components determines the degree of development of a particular defect. Thus, the frequency analysis of the spectrum of the vibration signal makes it possible to determine both the defect itself and its location [3]. It should be noted that different methods for detecting defects are in varying degrees sensitive to different degrees of development of a defect in a controlled object. For example, spectral analysis, as a rule, begins well to identify defects at their middle stage of development [4].

Monitoring and diagnostics based on vibration parameters can be applied at any time, even after several years of equipment operation, when the costs of preventive maintenance and repair will exceed the economically justified value. The diagnostic program automatically, knowing the rotational speed, finds all the characteristic frequencies of the bearing elements (cage, rollers, rings), determines the amplitude of these harmonics, and stores it. After collecting the required statistical sample, it determines and calculates the standard deviation (RMS). The standard deviation is used to determine the measure of the spread of a random variable.

To increase the efficiency of diagnostics, successive refinements of the diagnostic algorithm are necessary with the accumulation of sufficient information. Thus, the work will consider the issue of developing an application for vibration diagnostics of bearings, this application should help in checking bearings without disassembling the friction unit itself.

1. Analysis of technologies of development of web applications

The development of a web application consists of many stages, the difference in the cost of the site will depend on the amount of time that a software engineer needs to spend to implement certain functionality. Today, website developers have a wide variety of choices regarding which language (or technology) to use to build a website. There are many options: Perl, PHP, ASP,

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ASP.NET, JSP, Coldfiisio, etc. The most common (by a large margin from the rest) today are PHP and ASP.NET [8].

PHP (Hypertext Preprocessor) is a language for writing server-side scripts. The language interpreter is free and open-source, versions have been created for various web servers, primarily for Apache and Internet Information Services [2].

The advantages of PHP are: fast customization of a ready-made solution (for example, overlaying a new design on an existing site, which is managed by a CMS); a large number of free solutions on this platform; absolute free of charge; simplicity of language; any data in a language can implicitly be textual.

ASP.NET (Active Server Pages .Net) is a tool for developing web applications from Microsoft. Asp.net is not a programming language, it is a technology that includes many components [7].

The advantages of ASP.NET include: availability of visual programming tools – reducing development time by 2 or more times; implementation of the application object model; executable code – compiled application; Microsoft.net technology support is built into Microsoft OS; built-in support for AJAX technology – any form element can be executed in the "classic" native version or using AJAX [7].

For an experimental study of the effectiveness of development technologies, it is necessary to create a website and evaluate which technology made it possible to achieve the set goals as much as possible while spending a minimum amount of time and effort to implement the project.

Thus, after the implementation of the project, it is necessary to analyze the development process and identify by means of which technology it was possible to achieve the maximum result, and estimate the time during which this result was achieved.

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To implement this system, the following set of subsystems is required:

1) Application with a graphical interface for Windows.
2) Api – a server application for working with data written in php.
3) MySQL – a database for storing registered users and data on diagnostics of functional units, which is not desirable to replace, otherwise you will have to rewrite most of the server application.
4) Chrome, since the application is written based on a chrome application in JavaScript, and if it is replaced, you will have to rewrite almost the entire client application.

1.1. Functional requirements

In this subsection, we will define what functionality will be in the application. To do this, we will use a use case diagram.

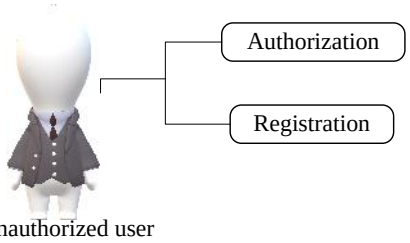

Fig. 1. Diagram of application use cases for an unauthorized user

Figure 1 shows a diagram of the application use cases for a user who has not yet been logged into the application. This diagram shows that to access any functions of the application, you must have your account in this application.

1) Authorization. The first thing a user needs to start working on the application is to log in to the system using their account. As soon as the user is logged in, the application creates a request through the server to the database and checks if this user exists with this password. If such a username and password are in the database, then an answer comes about the authorization of the user, if such a user was not found, then the answer comes that "The username or password was entered incorrectly.
2) Registration. If the user does not have an account, then his first step is to create an account before he can start working in the application. When the user clicks the registration button, the application opens the corresponding form, which he must fill out. Upon completion of this, a request will be created, and as a result of the execution of which a new account will be created in this application with the data of this user. Then he will be able to start working on this application.

Figure 2 shows a diagram of the use cases for the application. This diagram shows all the capabilities of this application from the point of view of a simple Operator and Administrator. The following main factors can be distinguished that interact with this system.

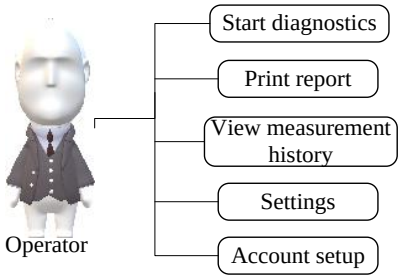

Fig. 2. Diagram of application use cases after authorization in the system

1) Operator (Administrator). An application user is an operator who performs the actual diagnostics of a functional unit or an administrator who is responsible for the system's performance, the work of operators, etc. Depending on the role, the user is assigned different access rights. So, for example, if a user has administrator rights, he can not only view the history of diagnostics of all functional units but also change or even delete any of the accounts of any of the operators.
2) To start diagnostics. After authorization, if the authorized user is the Operator, then he can start the calibration after he sets up the calibration process itself. And he can configure this in the diagnostic parameters, which can be set in advance.
3) To print the report. After completing the work, the operator can print the entire report for the entire working day. The report will indicate the number of the functional unit, the time when it was checked, which of the operators checked it, what indicators the operator received at the end of the diagnosis, and whether this functional unit is defective or not. But you can also get all this data for any period of work and any of the operators.
4) To view the history of measurements, for example, if at the end of the week you need to view the entire history of measurements and then print the necessary data for a certain period or a certain operator, then this can be done in this function. In other words, first, you view the history of all diagnostics, and then a report is generated based on this data and printed.
5) Diagnostic parameters. Before proceeding with the diagnostics, the operator must enter the appropriate parameters, which he can obtain by diagnosing the calibration pair, which is already with a defect in the bearing. Then he can proceed with the calibration of other functional pairs that need to be checked.
6) Setting up accounts. When a user is logged in and his account has administrator rights, then he has access to this function, which allows not only completely changing the account data, but also completely deleting the account. And the changeable data also includes the issuance or removal of administrator rights from any account.

When describing the architecture of the developed application, a general component diagram was designed to display the interaction of the logical parts of the application, which is shown in figure 3.

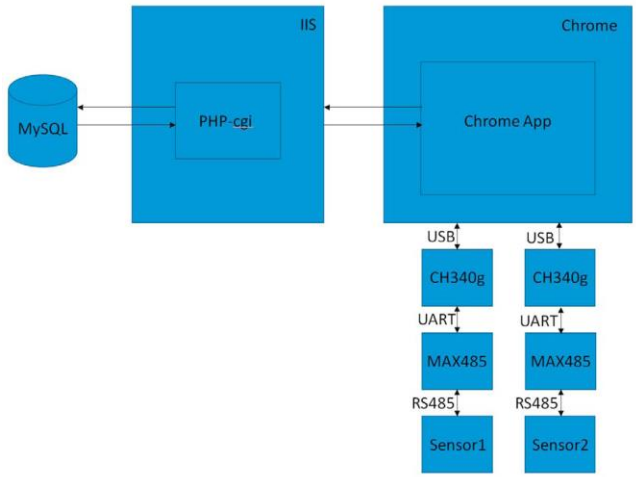

Fig. 3. Diagram of the components of the designed system

MySQL is the database that stores all measurement and account data for all operators.

PHP-cgi is an HTTP server with a back-end application on it, which processes data and requests from the client application and sends the necessary data from the database:

- add user – the function responsible for registering new accounts;
- change user – the function responsible for changing the account and for changing the account data;
- delete user – the function responsible for deleting an account;
- get measure chart – a function responsible for receiving "raw" data, that is, without processing;
- get measures –function responsible for obtaining measurement results after diagnostics;
- login – the function responsible for user authorization;
- save measure – Saving measurements obtained during diagnostics;
- user list – a list of all user accounts;
- auth is a function that is responsible for user authorization, that is, it checks the existence of a particular account.

Chrome App – A client web application that is responsible for obtaining data on the nodal pairs using two sensors that measure vibration and then receive the standard deviation, based on which you can find out whether the bearing is working or repairs are required:

- login – a function that generates a request to the server for user authorization;
- print – a function that is responsible for printing the generated report on the diagnostics of the bearings of the nodal pairs;
- start – the function responsible for the beginning of receiving data from sensors that measure vibration;
- disconnect – a function that is responsible for disconnecting an account, in other words, an exit;
- users – a function that opens a list of users who are registered in the system;
- history.cancel & history.filter – functions that are responsible for applying a specific filter in the history of all diagnostics per-formed, all functional pairs;
- save_measure – the function is responsible for saving the data that was received after diagnostics of the node pair;
- settings.cancel – the function that is responsible for canceling the settings, returning all diagnostic parameters to their default values;
- settings.start_calibration – the function responsible for starting the calibration, this is the diagnostics of the calibration functional pair, which is known in advance to be defective;
- users.add – a function that generates a request to the server to add new users, i.e. creating a new account;
- users.modal.add, users.modal.change, users.modal.delete – functions that are responsible for all operations that an operator with administrator rights can carry out, for changing account information, for deleting an account, for adding data to an account, for example, issuing administrator rights.

All data to the application is received and sent in JSON format. This format was chosen for readability and lightness, rather than, for example, XML.

1.2. Description of the database

The application has its own local database, which stores information not only about all accounts, but also about all performed calibrations, all node pairs. And all this information is stored in JSON format. List of tables and values:

Measuring table:

- ID (Integer) – identifier;
- calibration (TinyInt) – data obtained during the diagnostics of the calibration functional pair;
- wheelset_number (Integer) – number of functional pair;
- operator_id (Integer) – operator identifier;
- operator_opinion (Text) – operator's opinion, which he makes after diagnosing a functional pair;
- date (Biglnteger) – date of the diagnostics;
- sensor1 (Json) – sensor # 1;
- sensor2 (Json) – sensor # 2;
- sensor1_max_sko (Integer) – maximum RMS value from sensor # 1;
- sensor2_max_sko (Integer) – maximum RMS value from sensor # 2;
- sensor1_ max (Integer) – maximum value of raw data, without processing from the first sensor;
- sensor2_max (Integer) – maximum value of raw data, without processing from the second sensor:
- sensor1_solution (TinyInt) – shows the state of the functional pair to sensors # 1;
- sensor2_solution (TinyInt) – shows the state of the functional pair to sensors # 2.

Session key table:

- user (Integer) – data of the account of the operator who diagnosed one of the functional pairs;
- key (VarChar) – foreign keys;
- auth_date (TimeStamp) – date and time of the diagnostic session.

Users table:

- ID (Integer) – account identifier;
- login (VarChar) – account login;
- pass (VarChar) – account password;
- first_name (VarChar) – the name of the operator in the account;
- middle_name (VarChar) – middle name of the operator in the account;
- last_name (VarChar) – operator's surname in the account;
- admin (TinyInt) – the presence or absence of rights;
- deleted (TinyInt) – the account has been deleted or not.

2. Implementation of the application

The application was implemented in the Netbeans IDE, an open-source environment for software developers. The environment provides all the tools you need to create professional desktop applications, enterprise, mobile and web applications on the Java platform, as well as C / C ++, PHP, JavaScript, Groovy, and Ruby.

The client application was implemented in JavaScript (js) and the backend was implemented in PHP. PHP is a server-side programming language that runs on the server-side, while JavaScript is executed in the browser on the user side.

JavaScript – Supports object-oriented, imperative b functional styles. Plus, a large number of all kinds of frameworks have been created for it, sharpened for different tasks, and facilitating the development process.

PHP is a programming methodology based on representing a program as a collection of objects, each of which is an instance of a certain class, and the classes form an inheritance hierarchy.

Ideologically, OOP is an approach to programming to modeling information objects, which solves at a new level the main task of structured programming: structuring information from the point of view of controllability, which significantly improves the controllability of the modeling process itself, which, in turn, is especially important when implementing large projects.

After starting the application, the operator can log into his account and start his work, or find the necessary data and print it.

After going through the authorization process, the operator can immediately start diagnostics if the diagnostics settings have been preset. The operator can print a report on the diagnostics of functional pairs, absolutely for any period. The report will reflect all the information about each diagnostic process. Based on information from history, a report is formed and determined. In other words, in history, you can find out for what period the report needs to be generated for reporting.

3. Conclusion

The current state of technologies of vibration control of equipment with measurement of vibration parameters is considered and analyzed in the work. The simplest means of vibration control includes a measuring transducer, an analyzer (actually a vibrometer), as well as an external program for collecting and analyzing measurements. The issue of developing an application for vibration diagnostics of bearings is considered. All the main positions were analyzed that are associated with the design, development and commissioning of applications for vibration diagnostics of bearings of functional pairs of critical structures. The following tasks were completed:

1) The materials and experience of development in the field of creating web applications, conducting vibration diagnostics and checking bearings for wear using vibration diagnostics have been studied.
2) Analyzed technologies that will be useful in the development of this application and which will help to simplify its development.
3) Based on the data obtained, an application for vibration diagnostics of bearings of functional pairs of critical structures was developed and implemented.
4) The results were analyzed and the efficiency of the application for vibration diagnostics of bearings of functional pairs was determined.

The web application is fully implemented under the Windows operating system.

- As a result of the work done, the following conclusions can be drawn:
- the architecture of the application is built based on the chrome application;
- an application for vibration diagnostics of bearings of functional pairs of critical structures has been implemented;
- convenient search and automatic generation of reports of necessary data on diagnostics of bearings of functional pairs of critical structures is organized;
- a back-end application was developed to process the received data and interact with the database.

The work aimed at designing an application for vibration diagnostics of bearings will improve the efficiency of defect detection based on the results of vibration measurements and promptly eliminate detected bearing defects without disassembling the functional unit itself.

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