COMPUTER SCIENCE

COMPUTER SYSTEM OF COMPREHENSIVE ASSESSMENT OF TECHNICAL CONDITION OF FUNCTIONING OF MECHANISMS

[1]*Doctor of science* ***Shvachych G. G.,*** [1]*Doctor of science* ***Hrygorenko V. U.,***
[2]*Doctor of science* ***Kadylnykova T. M.,***
[3]***Sushko L. F.***

[1]*Ukraine, Dnipro, National Metallurgical Academy of Ukraine,*
[2]*Belarus, Pinsk, Polessky State University,*
[3]*Ukraine, Dnipro, State Agrarian and Economic University*

DOI: https://doi.org/10.31435/rsglobal_ws/30092019/6694

ARTICLE INFO

Received: 18 July 2019
Accepted: 19 September 2019
Published: 30 September 2019

KEYWORDS

computer system,
system window,
software,
equipment,
diagnostics.

ABSTRACT

The computer system proposed in this work is aimed at solving the problem of automating a comprehensive assessment of the technical functioning of mechanisms. The system's computational equipment have the minimum necessary computing requirements. No additional paid software is required for installation. Unlike existing systems, the proposed one has a moderate cost. For the majority of industrial enterprises, this factor is crucial when choosing the most beneficial computer system. In addition, the developed system is simple and comfortable to use. Thus, the system has an intuitive and intelligible interface for the operator, which allows the operator to quickly familiarize themselves with it and put it to use immediately; the system monitors the correctness entries in the electronic history - it corrects basic fields that are not properly indicated (repair data, repair requests, part price, etc.). The system has the ability to add individual templates for a specific unit. Unlike existing systems, the proposed system is multifunctional.

Citation: Shvachych G. G., Hrygorenko V. U., Kadylnykova T. M., Sushko L. F. (2019) Computer System of Comprehensive Assessment of Technical Condition of Functioning of Mechanisms. *World Science.* 9(49), Vol.1. doi: 10.31435/rsglobal_ws/30092019/6694

Introduction. Today, documenting the technical state of the functioning of mechanisms takes a large part of the working engineer's time, but is a necessary attribute of any technological institution. Nowadays there are systems for computer diagnostics of the technical state of mechanisms, but they are far from ubiquitously [1, 2]. Due to the increasing amount of information in the technical diagnosis arrangements, there is a need to automate processes of the basic flow of documents. Collection, storage, analysis of information, structuring the informational flows, their distribution, and other operations with diverse types of data are impossible without the use of computer technology.

However, note that computer systems for diagnostics automation of mechanisms and machines, are perhaps the most frequently changed component in the management structure of a modern enterprise. In addition to the traditional directions of modernization, one of the recently demanded ways of developing computer systems is the integration of systems of various levels of control. Technological safety management is added to the list of functions of these systems.

A variety of hardware and software, structural and architectural solutions, functional capabilities, as well as various degrees of participation of information tools in production and enterprise technology control channels are the main defining characteristics of existing computer automation systems in modern enterprises, in all industries. The management of the automation departments of various enterprises have problems regarding choosing the path of further system development.

On the one hand; the volume of automation, the complexity, and the cost of hardware and software have increased. Along with this, the expenses of resources and time for design work as well as the requirements for the qualification of staff and maintenance costs have also dramatically increased.

On the other hand, there is a “patchwork” nature of automation in general, at all levels of management, as a result of which there are losses i.e. non-compliance with the regulations: violations of the operating standards of equipment. Production losses are frequent due to conflicts in the flow of “technological actions” planned by staff who control the technological processes of repair and preventive work, which is organized at the level of production management. The "transparency" of the processes for monitoring the technical diagnostics of systems for external technology control loops is insufficient. In addition, it should be noted that so far, the coordination of actions has been minimal. This was due to the various requirements of the departments and services of enterprises utilizing multiple means of automating the process of system diagnostics.

Analysis of recent research and publications. There are several effective methods for detecting major defects in machines and equipment based on vibration during their inception stages [3]. They are based mainly on the analysis of high-frequency vibration and are manifested only in the places of its action, quickly attenuating during propagation. These methods have been used by scientists in many countries to move from vibration monitoring to deep diagnostics [4, 5]. At the same time, computer systems diagnostics were developed, which allowed a number of manufacturers of diagnostic systems to replace high-quality experts in solving typical diagnostic problems with the software [6, 7]. Their portion is very high and exceeds ninety percent of all existing tasks that are solved by analyzing vibration signals. First computer systems for vibration diagnostics were developed in 1991-1992 and are constantly being improved [8, 9]. Over the last twenty years, a whole new generation of the systems of computer diagnostics based on vibration has emerged. It has been developed by various specialists and has combined both monitoring and diagnostic systems [10, 11].

The principles of observing the dynamic state of the rotating elements of machines and mechanisms have become widespread. In particular, gears. The process carried out through the tracking of accelerations in certain places and subsequent processing of the obtained measurements. The sensor signals are fed through an amplifier to an electronic unit containing an analog-to-digital filter and then processed by a personal computer, resulting in a spectrum of signal intensity distribution over frequencies. Modern frequency analyzers have automated special filters that filter out erroneous signals. Computer systems can give frequency spectra with so-called intensity peaks, on the basis of which it is possible to conclude about the nature of the damage and the place of their occurrence [12].

In assessing the technical state of the mechanisms, methods of nondestructive testing have acquired great importance. [13] outlines of the basic methods of non-destructive control of materials in terms of the application of fracture mechanics for the needs of technical diagnostics of structural integrity. The constructive numerical-analytical method of interaction of electromagnetic waves with the formed defects of the material is developed. Herewith great importance is given to the use of ultrasonic computed tomography. In [14] it was proved that the combination of ultrasonic methods of non-destructive testing and information technologies of computed tomography allows creating qualitatively new technologies of ultrasonic control which solve the problems of reconstructing the spatial distribution of material properties in the volume of a product.

Computer simulation of the dynamics of vibration systems is presented in [15]. In particular, it justifies the feasibility of using computer support for the process of technological modeling with the help of packages of applications adapted to the creation of databases and expert systems of vibration technologies.

The process of computerization of diagnostics has opened wide prospects in predicting the efficiency of mechanical transmissions and the creation of automated systems for assessing the technical condition and durability of transmissions, which were reflected in the publications [16, 17].

In [17], the organization of computer control of the technical inspection of machines is presented. The software includes four programs: a process visualization program that allows to

monitor the progress of the tests on all 12 machines which included in the installation; a program for entering data, starting or stopping tests and presenting results; communication program between personal computer and data logger; spreadsheet program for calculating physical parameters, controlling boundary parameters and regulating the process.

Thus, designed computer systems for assessing the technical state of objects differ in the variety of control models used, the degree of compliance with the requirements of the system approach, the number of hierarchical levels, and the complexity of algorithms for processing information. This means that the task of minimizing the cost of servicing computer systems for the technical diagnostics of mechanisms must be solved individually for each company.

Analysis of the market for automated software products showed that all analog systems are different in their functional content. However, it was revealed that most of the software products in use are expensive. The aforementioned allows to state that the development of computer systems for technical diagnostics of mechanisms for a particular enterprise remains an issue of the day.

Unsolved part of the problem. Existing computer systems for an integrated assessment of the technical state of the functioning of mechanisms are not always suitable for a number of enterprises. The reason for this may be the accuracy of data presentation, speed of information processing, memory requirements for computer tools, and the structure of algorithms. The situation becomes more complicated by the fact that usually each of the computer systems diagnostic mechanisms were implemented on the basis of various hardware, software and information standards. Lack of regulatory services and a unified standardization of management tools leads to unreasonably high costs for maintenance and modernization of equipment. Hence arises the urgency of the creation of modern computer systems for an integrated assessment of the technical state of the functioning of mechanisms taking into account a single information space.

The purpose of the study. The main objective of the developed information system is a complex solution for the collection and analysis of information about the technical condition and functioning of mechanisms as well as the management tasks of the enterprise in general. Respectively, specific tasks are solved for each unit of the enterprise. However, difficulties in determining the main focus or priorities of the enterprise's activities significantly complicates the development and implementation of such information systems. The developed computer system primarily optimizes information gathering, helps an engineer in monitoring and diagnosing the technical condition of the functioning of mechanisms, as well as aid in reducing errors and eliminating negative consequences. The existing experience in the developing of information systems allows one to conclude that as a result of designing such a class of systems, it is necessary to pay attention to both the diagnostic component (the decision support function) and the statistical component (analysis of heterogeneous data, reporting for analysis and forecasting of the functioning of mechanisms), and also economic (optimization of the financial activities of the organization).

Basic results of research.

***Basic principles of creation of the computer system*.** The process of automating the information support of the processes of monitoring the status and maintenance of technological equipment is based off the following principle: at the first stage, the operator enters information into a single database of equipment status for the current period. At the second stage, this information goes to the person in charge, who decides on the appropriate equipment work that needs to be done.

If the decision is made to perform certain work tasks with equipment and mechanisms, then:

– data on necessary work are entered into the computer system;

– the entered data goes to the operators through the means of a computer system;

– after completing certain work tasks, data on performed actions is entered.

Diagnostics of equipment occurs at one- month intervals, carried out by the specialists responsible for it. The reports give indications of the current status of the equipment. It also contains information about the condition of the equipment at the beginning of the month, possible problems with the equipment, and recommendations for further work.

The context diagram of the developed computer system is shown in Fig. 1.

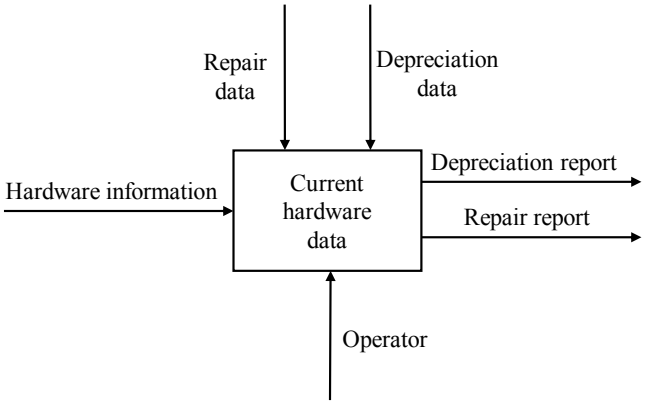

Fig. 1. The context diagram of the developed computer system

Fig. 2 shows a diagram of the interaction of users of a computer system. It schematically shows an embodiment of use of the application and records about user activities.

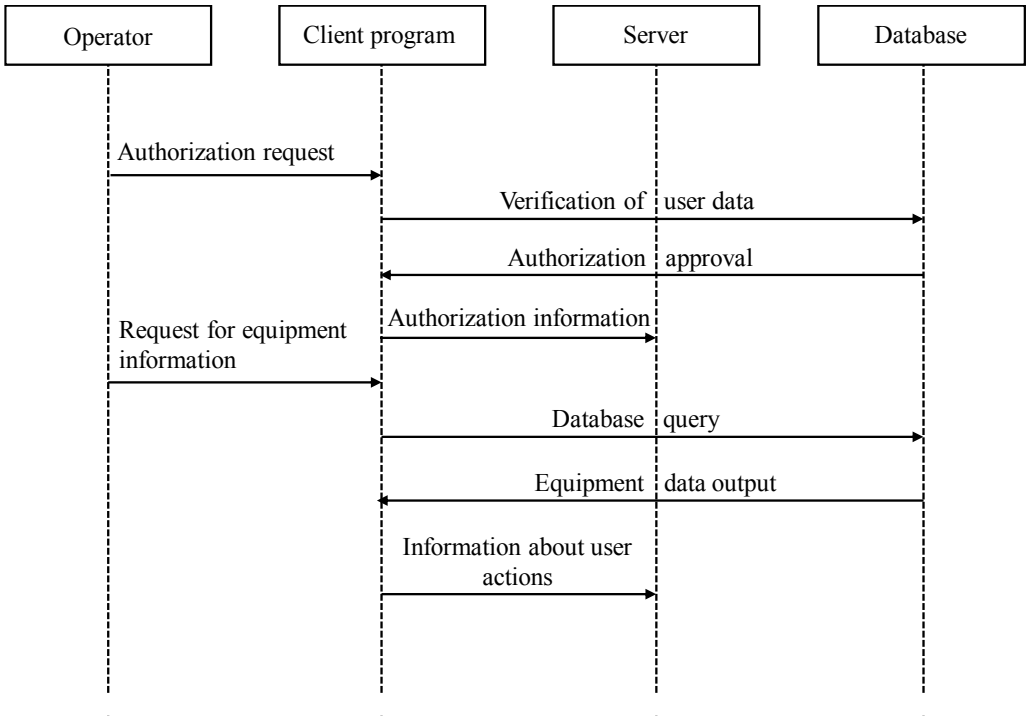

Fig. 2. Computer system user interaction diagram

The following servers were used to implement a computer system:

– database server;

– application server;

– client workstation.

Input and output data of the system. The input data of the system includes data on equipment, data on guarantees, warranty information, data on checking the condition of the equipment. The output data includes information on depreciation, information on repairs performed, information on contracts, equipment health check information. In addition, it is possible to output the data on depreciation of the equipment in and Excel file and sort it by year, as well as output the data on specific repair work in a Word file.

Design features of the computer system. The following tables were created during the design of the computer system:

– table “Depreciation” stores information on depreciation of the equipment;

– table "Equipment" stores information about the types of equipment in manufacturing;

– table "Repair" stores information about the repair work performed;

– the "Employees" table stores information about employees;

– the "Authorization" table stores information about authorization data;

– table “Reports” stores the information about authorization data;
– the “Inspection” table stores information about equipment inspections.

The principal feature of the created tables is the organization of connection between them. In this connection, one of the main requirements for the organization of the developed database is to provide the ability to find certain entities according to the purposes of others, so that specific connections are established between them. The connection between the created software products is presented in Table 1.

Table 1. Classification of relationships between tables

Linking number	Parent table	Subsidiary table	Type of connection
1	Equipment	Depreciation	M:1
2	Equipment	Repairs	M:1
3	Repairs	Employees	1:M
4	Repairs	Reports	1:M

Note that the database also has a table that has no connection and serves to authorize users.

The database that stores the necessary information was developed and created based on the constructed models. To describe the basic principles of the website, various UML diagrams were compiled. They show the logic of the computer system in more detail.

Basic requirements for software and hardware. The following development and storage tools were used to create the computer system:

–Microsoft SQL Server Management Studio — to store the data;
–Microsoft Visual Studio 2019, programming language C# — for the development of software product.

Microsoft Visual Studio — Microsoft product line, including an integrated software development environment and a number of other tools. The main feature of this product is that it allows the development of both console applications and graphical user interface applications (GUI) including support for Windows Forms technology. In addition, this product aids in the development of websites, web applications, web maintenance services in both your own and managed code, as well as for all platforms supported by Microsoft Windows, Windows Mobile, Windows CE, .NET Framework, Xbox, Windows Phone .NET Compact Framework and Microsoft Silverlight [15].

Visual Studio consist of:

–VisualBasic .NET (Visual Basic slightly differ by syntaxes);
–Visual C++;
–Visual C#;
–Visual F# (starting from VB2010).

As an object-oriented language, C # supports the concepts of encapsulation, inheritance, and polymorphism. All variables and methods, including the Main method - the application entry point - are encapsulated in class definitions. A class can inherit directly from one parent class, but it can implement any number of interfaces. In addition to the described basic object-oriented principles, C # simplifies the development of software components through several innovative language constructions, which include the following:

– encapsulated method signatures, so-called delegates, that support type-safe event notifications;
– properties acting as accessor methods for private member variables;
– attributes with declarative metadata about types at runtime;
– inline comments of XML documentation;
– LINQ, which offers built-in query capabilities in various data sources.

The developed computer system also uses Microsoft SQL Server - relational database management system (RDBMS) developed by Microsoft Corporation. Primary query language used – Transact-SQL, created jointly by Microsoft and Sybase. Transact-SQL is an implementation of the ANSI / ISO standard for structured query language (SQL) with extensions. This approach is used to work with databases ranging in size from personal to large databases of the enterprise scale; competes with other DBMS in this market segment.

The considered database design environment is the best option for the developed computer system, since it is convenient in creating databases, has an accessible and intuitive interface, and

allows the transfer of the database from one computer to another, without requiring additional software. The above features of the design environment are crucial due to the fact that the developed computer system will be installed on various types of computer equipment.

Recommended hardware requirements: CPU: Intel Pentium Xeor; RAM: no less than 128 MB; free disk space: at least 1 GB.

The basic principles of the functioning of a computer system. When starting the computer system, the login window will appear. In this window, the username and password of the operator needs to be specified. After the system authorization, it will open the first software tab (Fig. 3).

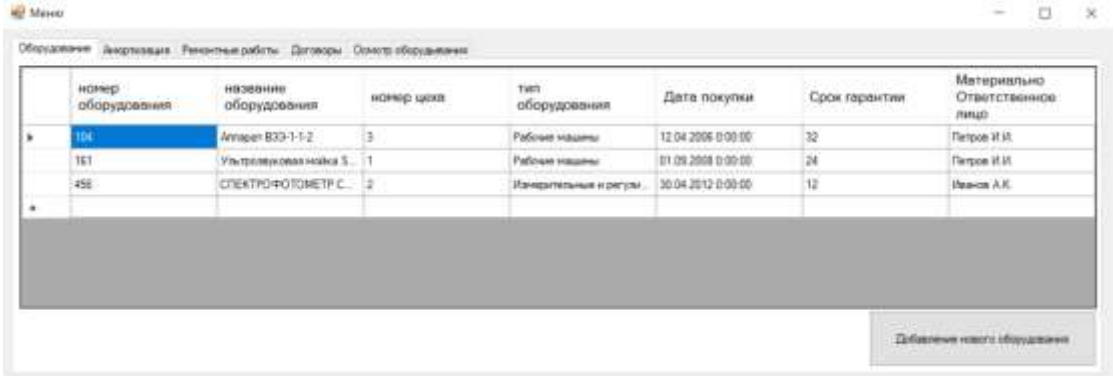

Fig. 3. Starting system tab

System user can input new equipment data. For this purpose, the button “add new equipment” has been formed. This opens a new window (Fig. 4), in which the operator enters the necessary equipment data.

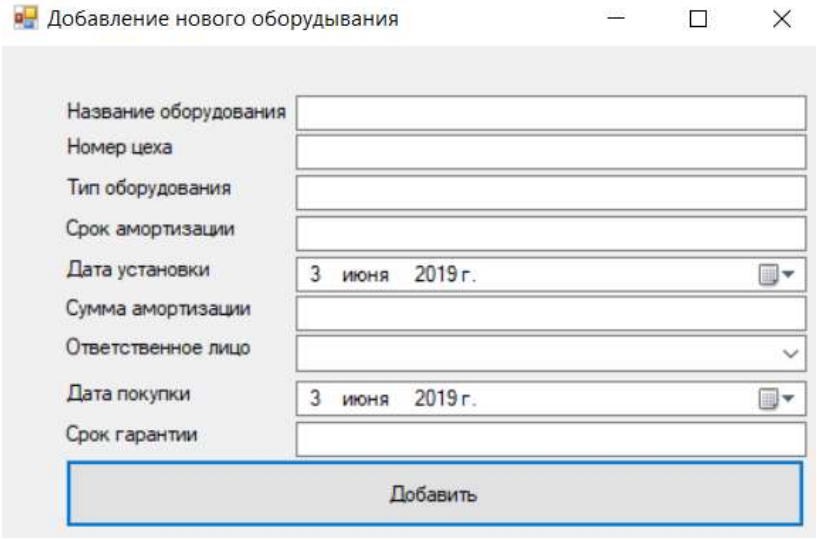

Fig. 4. View of the “Add new hardware” window

To add new data, each field is filled with the required information. Then, after clicking the “Add” button, a notification message appears. The window with depreciation data is shown in Fig. 5.

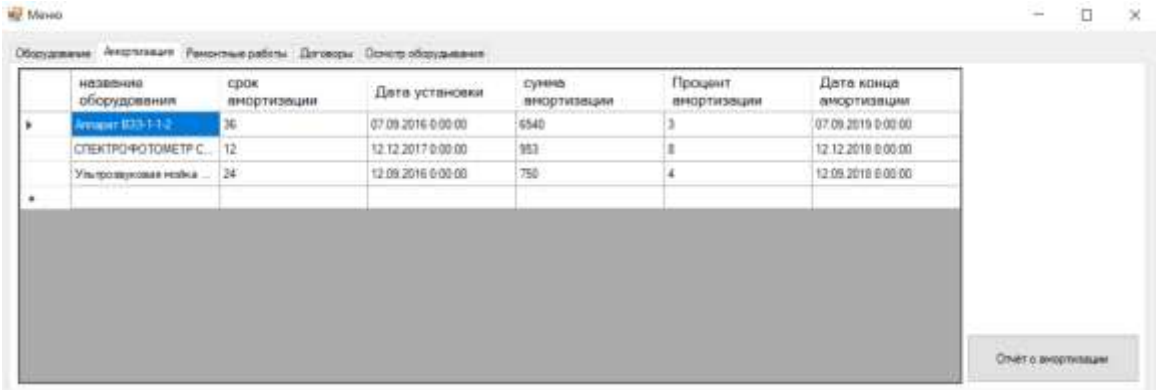

Fig. 5. View of the “Depreciation data” window

When clicking on the "Depreciation Report" button in a new window, after filling out the necessary forms, depreciation data is displayed. Such data, in addition to the system window, can also be displayed in the format of the Excel environment. The general view of the depreciation report system window is shown in Fig. 6.

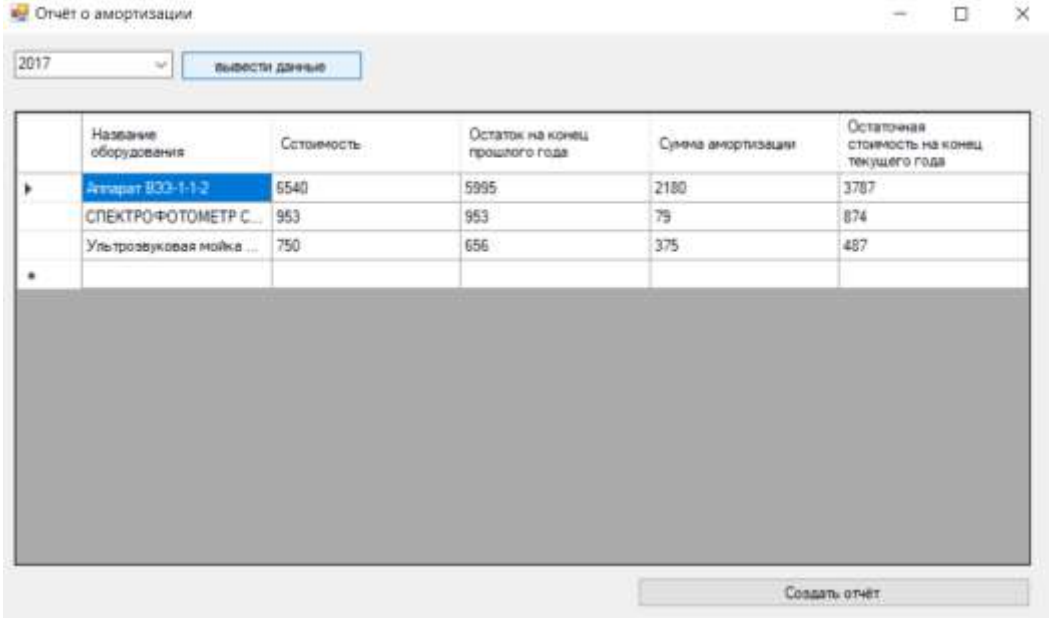

Fig. 6. View of the "Depreciation report" window

Data on the repair work being carried out are generated in the "Repair work" window, a general view of which is shown in Fig. 7.

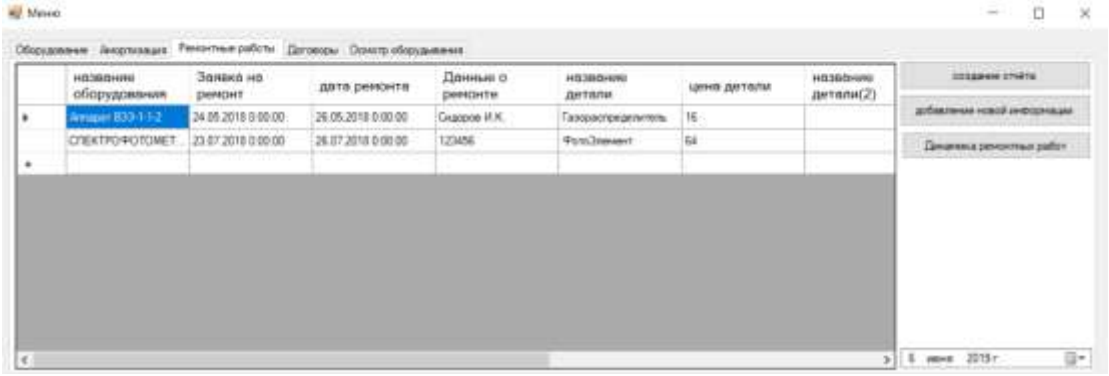

Fig. 7. General view of the window "Repair work"

To add new work performed, refer to the "add new information" button. In this case, in the window that opens, the operator enters the necessary data.

The user of the computer system is given the opportunity to make the required report and print it out. Here also can be generated a report on the dynamics of the work performed for each type of equipment.

Conclusions. The developed computer system solves the problem of automating an integrated assessment of the technical functioning of mechanisms. The proposed system has the following qualities. First of all, it is ideal for its moderate cost, which is one of the decisive factors for most industrial enterprises when choosing a computer system to use.

Secondly, the proposed system is simple and comfortable to use. The system has an intuitive and understandable interface for the operator, which allows the operator to quickly go through the familiarization stage and increase effective use and productivity; the system monitors the correctness of filling in the electronic history fields - it will correct, if basic fields are not indicated (repair data, repair requests, part price, etc.).

The system has the ability to add users' own templates for a specific unit. When working, it displays only system templates and does not display a huge list of additional embedded templates, i.e. has customization feature for a specific workplace. The system includes a built-in, editable directory of necessary parts and equipment.

Another advantage of the developed system is its stability and reliability. At the same time, the system containing important information about the enterprise is not only stable in operation but also protected from unauthorized access attempts. In addition, it is multifunctional and easily adapts to the profile of the unit.

The computer system is constantly updating, taking into account the wishes of its users. Also, it has minimal requirements for the computer hardware. No additional paid software is required to install the system.

REFERENCES

1. Соболев В.С. Программное обеспечение современных систем сбора и обработки измерительной информации. Сборник научных трудов Приборы и системы управления. 1998. 1: 55-63.
2. Pokojski J. Komputerowe wspomaganie decyzji wielokruterialnych u dynamice maszyn. Pr. nauk. Mech. Pwarsz. 1990: 108.
3. Генкин М. Д., Соколова А. Г. Виброакустическая диагностика машин и механизмов. Монография. – М.: 1987: 282.
4. Kaharaman A, Singh R. Non–linear dynamics of a spur gear pain. Journal of Sound and Vibration. 1990. Vol 142, 1: 49-75.
5. Muller L. Diagnostyka przekladni zebatych duzych mocy: Referat przedstawleny na 20 symp. “Diagnostyka maszyn”; 25 konf. “Przekladnie zebate”. –Gliwice, 1992: 88.
6. Бывайков М. Е. Исследование и разработка алгоритмов и программных методов для прогнозирования трендов параметров технических объектов. Автореф. дис... канд. техн. наук. –М.: 1989: 17.
7. Фирсатов В. Г., Застрогин Ю. Ф. Кулбянин А. З. Автоматизированные приборы диагностики и испытаний. Монография. –М.: 1995: 345.
8. Современные методы и средства виброакустического диагностирования машин и конструкций. Ф. Я. Балицкий, М. Д. Генкин, М. А. Иванова и др. под редакцией академика Фролова К. В. Монография. –М., 1990: 252.
9. Косарев О. И. Вибровозбуждение и динамические нагрузки в цилиндрических зубчатых передачах. Дис…. канд. техн. наук., –М., 1997: 250.
10. Wavelets for mechanical and structural damage identification/ Staszewski W. J. –Gdansk, 2000: 175.
11. Vibrations / W. Bogus, Z. Dzygadlo, D. Rogula. Et al. – wars zawa: PWN; Dordrecht et all.; Kluwer acad. publ., 1992: 488.
12. Luft G. Grundlagen rechnergestutzer Maschinenuberwachung und praktische Anwendungen. Messen und Prufen. 1991.3: 92-96.
13. Механіка руйнування і міцність матеріалів/ Довід. Посіб. Т.5. Неруйнівний контроль і технічна діагностика / З.Т.Назарчук, В.В.Кошовий, В.Р.Скальський, О.П.Бухало, Р.А.Воробель. Фіз.-мех. Ін.-т ім. Г.В.Карпенка. – Львів. 2001: 1134.
14. Кошовий В.В., Назарчук З.Т. Про оцінку перед дефектного стану матеріалу засобами ультразвукової обчислювальної томографії. Фіз.-хім. Механіка матеріалів. – 2001. 37(2): 118-132.
15. Яковенко В.Б. Элементы прикладной теории вибрационных систем / Яковенко В.Б. – К., Наукова думка, 1992.– 218 с.
16. Pokojski J. Komputerowe wspomaganie decyzji wielokruterialnych u dynamice maszyn. Pr. nauk. Mech. Pwarsz. 1990.134: 3-108.
17. Hauke J. Automatische Zeitstandprufung mit PC. Materialprufung, 1990, 11: 342.
18. Фаулер М. Шаблоны корпоративных приложений. – М.: Вилбямс, 2016: 548.