MECHANICS

DOI: 10.15587/2312-8372.2019.181523

DETERMINATION OF REMAINING RESOURCE OF CONSTRUCTIONS OF BUILDINGS AFTER DIFFERENT INFLUENCES

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The object of research is the residual resource of the structures of buildings and structures after various influences. The residual resource is the total operating time of the object from the moment of monitoring its technical condition to the transition to the limit state.

The calculation methods recommended by the current regulatory documents of Ukraine do not allow predicting the probability of failures, an increase in the number of structural defects and deformations over time and really assessing the possibility of further operation in such conditions. One of the most problematic places is determination of the technical condition of structures of buildings and structures operating under various influences (in an aggressive environment, with forced displacements of supports, possible high-temperature influences, etc.).

It is shown that the residual life of the structures of buildings and structures that suffered damage during operation after various influences can be reassigned due to reinforcement. In this case, the main question remains the determination of the physical and mechanical characteristics of the materials that were used in the manufacture of structures, as well as the calculation of structures for the justified purpose of the cross sections of reinforcing elements. Characteristics of materials are determined during the observation. During the observation, various methods were used to determine the physical and mechanical characteristics of structural materials (concrete, reinforcement, steel, brickwork, etc.), which are usually non-destructive. Non-destructive methods can be applied in cases where this is possible under the conditions of operation of structures, for example, the removal of fragments of metal, reinforcement or concrete from lightly loaded elements.

The possibility of reassigning the residual resource is determined by comparing the values of the bearing capacity of the structures with acting values. The bearing capacity of the structures is determined using the values of the characteristics of materials and parameters (cross-sectional dimensions, geometric dimensions taking into account corrosion wear, etc.), which were obtained during the observation. The magnitudes of the forces acting in the structures of buildings and structures are determined by modeling their work using the finite element method and modern computing systems. Thanks to this procedure, it is possible to obtain the efforts that could arise in the structures of the building and reinforcement. Thanks to this, it is possible to make a decision on the reassignment of the remaining life of the structures, that is, the possibility of further operation, the need for reinforcement or replacement.

Keywords: structures of buildings and structures, defects and damages, inspection, structural analysis, residual life.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

DOI: 10.15587/2312-8372.2019.183883

EXERGY ANALYSIS OF A COGENERATION SYSTEM FOR UTILIZATION OF WASTE HEAT OF INDUSTRIAL ENTERPRISES

page 10–21

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The object of research is the energy processes occurring in the cogeneration system for the utilization of waste heat of industrial enterprises, consisting of a steam turbine plant and an absorption heat pump. One of the most problematic places during the development and design of such systems is that the thermal calculation of absorption heat pumps as a whole is a rather difficult task. This is due to the presence of several interconnected heat exchangers and the complexity of the thermodynamic and mass transfer processes occurring in them. During the research, modern methods of analysis of thermodynamic systems were used, based on the application of the theoretical apparatus of technical thermodynamics and the theory of heat and mass transfer. On the basis of mathematical modeling of heat and mass transfer processes for the cogeneration system under consideration, a software package for calculating its thermodynamic and exergy characteristics is built with the aim of conducting numerical studies of its energy efficiency indicators. A database is obtained for calculating the thermophysical properties of a water-ammonia solution taking into account changes in its concentration to identify the solution state parameters at the nodal points of the cycles. Based on a numerical experiment, the energy and exergy parameters of the system are analyzed with a variation of 4 factors:

1) condensation temperature of the spent water steam in a steam turbine plant;

2) heating process water temperature at the inlet to the steam generator of the steam turbine plant;

3) reverse delivery water temperature at the inlet to the heat pump;

4) mass flow rate of delivery water.

A generalized regression equation of the functional relationship of the exergy efficiency of the elements of the cogeneration system and the entire system as a whole is obtained. The impact coefficients of exergy efficiency of elements on the thermodynamic perfection of the entire system are analyzed. Thanks to the method of exergy analysis used in the research, it is possible to identify the nature of external and internal losses both in cycles in general and in individual elements of the cogeneration system under consideration. And also the ways to improve its scheme and design are outlined.

Keywords: exergy analysis, steam turbine plant, absorption heat pump, waste heat utilization.

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ALTERNATIVE AND RENEWABLE ENERGY SOURCES

DOI: 10.15587/2312-8372.2019.183054

RESEARCH OF THE OPERATION EFFICIENCY OF VEGETABLE BIOMASS-OPERATED SOLID FUEL BOILER

page 22–28

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The object of research is the process of ensuring uniform distribution of fuel over the combustion surface of the combustion chamber of a solid fuel boiler operating on biomass. The uniform distribution of fuel over the combustion surface is one of the important levers for eliminating the phenomena of its chemical and mechanical under-conditioning, which increases the efficiency of boiler equipment. One of the problems of studying this issue is the lack of a sufficient theoretical base and practical experience in the process of chemical-thermal conversion of plant biomass to other types of energy.

An approach is proposed based on the hypothesis that it is possible to increase the efficiency of boiler equipment on plant

biomass by establishing an intensive and high-quality combustion process, ensuring an even distribution of fuel on the combustion surface. And also to identify patterns and indicate methods for optimizing the structure of boiler equipment designs by adapting it to plant materials. The implementation of this approach is carried out by conducting a multivariate experiment. During the experiment, the dependence of the coefficient of uneven distribution of fuel along the combustion plane on the height of the loader nozzle, the angle of inclination of the loader control plate to the surface of the combustion mirror and mass fuel supply is determined.

As a result of the study, practical results are obtained, mathematical dependences of the coefficient of uneven distribution of fuel over the combustion surface on the indicated variable factors in the form of a second-order polynomial are presented.

The obtained research results will improve the efficiency of the process of heat production from low-grade solid fuels of vegetable origin in boiler plants, facilitate their wider use, and increase the environmental component of the process.

The research results are interesting both for manufacturers of boiler equipment based on vegetable raw materials and for its users who want to burn the biomass available on the farm to meet energy needs.

Keywords: boiler equipment, combustion surface, pneumatic-mechanical loader, vegetable biomass.

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REPORTS ON RESEARCH PROJECTS

DOI: 10.15587/2312-8372.2019.183874

DEVELOPMENT OF THE ORGANIZATIONAL PRINCIPLES OF FORMATION OF THE OPTIMAL DIAGRAM AND PARAMETERS OF VIBRATION SYSTEM

page 29–31

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The general issues of the development of an optimal circuit diagram of a vibration system and determination of the parameters of this circuit providing an extreme criterion of optimality are considered. The object of research is technical machines and technological media, which are considered as a system subordinated to a single vibration process. By technical machines, vibration machines adopted in the work for the implementation of compaction processes are adopted. Technological media adopted two-phase dispersed media used for compaction. Concrete mixes and soils are accepted by such media. Reducing energy costs, a high level and speed of energy transfer to the process are the main factors in creating optimal schemes of vibration systems. One of the most problematic places in solving this approach is the lack of a generally accepted model for the interaction of the working bodies of machines with the processing medium. Existing studies are based on the separate determination of the parameters of machines and media. Such methods are characterized by significant energy costs and a long duration of the process. The proposed approach based on the harmonization of the forces of machines and media arising in the vibration process, has significantly reduced energy costs. The work also obtained a new synergistic effect of the system. This is due to the fact that the proposed method for creating the optimal circuit has a number of features. So, in the course of the study, the modes of combining the elastic-inertial forces of the subsystems in a single system are used. Particular implementation of subresonance and superresonance modes are determined. Thanks to this, it is possible to maximize the effectiveness of vibration systems not only in new design solutions, but also in the targeted use of the internal properties of the integrated system. Compared with similar well-known vibrating machines, energy costs are reduced by 50 %. The proposed methodology for developing organizational principles for the formation of the optimal scheme and parameters is used in the design of vibration systems for vibration and vibration-shock modes of compaction of building mixtures.

Keywords: organizational principles, optimal circuit, vibration system, optimality criteria, circuit parameters, subresonance and superresonance modes.

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DOI: 10.15587/2312-8372.2019.183264

NUMERICAL-EXPERIMENTAL RESEARCH OF TECHNOLOGICAL EQUIPMENT FOUNDATIONS IN DYNAMIC IMPACT CONDITIONS

page 32–35

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When designing new production workshops or reconstructing existing ones, the urgent issue is to take into account not only all static loads, but also possible dynamic effects caused by unsteady operation of technological equipment. In the work, on the example of examining the technical condition of an industrial building, the structures of which are subjected to dynamic effects from the action of technological equipment, an experimental-numerical approach to modeling the design situation, determining the causes of deformations and choosing a reinforcement method are considered. The object of research is the process of dynamic deformation of a separately located foundation of technological equipment – a woodworking machine, in the conditions of existing production. The research is aimed at finding a constructive solution to the problem of transferring vibrations from the machine's engines through its own foundation and soil base to the foundations and load-bearing elements of the building of the production workshop. The main idea of the experimental-numerical approach is a comparison of the results of numerical and field measurements of vibration parameters. Numerical analysis is performed on the basis of finite element calculation using modern software systems, field

measurements are vibration records recorded using a seismograph, based on which the vibration spectra of the structure are constructed, from which the dominant vibration frequencies are determined. The phenomena of the internal resonance of the structure, discovered on the basis of comparisons of the results, make it possible to clearly formulate the causes of cracks in the structural elements.

The research results are used in the design of new and restoration of existing bases of technological equipment during the overhaul of the construction of the workshop and technical re-equipment of production.

The application of an experimental-numerical approach for the analysis of initial data in the design or reconstruction of structures, in the presence of unsteady vibrodynamic loads, allows to build a mathematical model as close as possible to the real one. The obtained research results can be used in the development of methods and technologies for diagnosing supporting and enclosing structures of structures under the influence of dynamic load.

Keywords: survey of the structure, vibration diagnostics, natural frequencies of vibrations, cracking, dynamic loading, finite element model.

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DOI: 10.15587/2312-8372.2019.183853

ANALYSIS OF ENERGY CHARACTERISTICS OF ABSORPTION WATER-AMMONIA REFRIGERATION MACHINES IN THE WASTE HEAT RECOVERY SYSTEMS OF GAS TURBINE INSTALLATIONS ON GAS MAIN PIPELINES

page 36–40

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One of the promising ways to reduce operating losses in main gas pipelines is pre-cooling of compressed gas using heat-using absorption water-ammonia refrigeration machines (AWRM), which utilize the waste heat of the exhaust products of the combustion of gas pumping units. The object of research is the energy characteristics of the AWRM in a wide range of operating parameters (outdoor temperatures), which are currently not studied. A methodology for modeling AWRM modes is developed, analytical studies are conducted and the results are obtained in a wide range of outdoor temperatures.

The study is conducted using theoretical analysis of AWRM cycles in a wide range of outdoor temperatures and temperatures of the cooling object. The analysis of the calculation results showed that in the range of design parameters there is a maximum energy efficiency AWRM. The most obvious is the presence of a maximum for operating conditions at cooling medium temperatures of 20...32 °C and low temperatures of the cooling object (minus 25 °C). As the temperature of the cooling object decreases, the maximum energy efficiency shifts to the region of high temperatures of the heating medium, and its numerical values decrease. At heating source temperatures from 90 °C to 130 °C, the electric power of the circulation pump has a maximum value. Subsequently, with an increase in the temperature of the heating source, its asymptotic decrease and slow decrease are observed. In this case, the greatest changes occur at elevated temperatures of the cooling medium (32 °C).

The simulation results allow to determine the most energy-efficient operating modes of the AWRM with various sources of

thermal energy (temperatures from 90 to 160 °C) and to develop cooling systems for a wide temperature range (minus 30...15 °C). To achieve such optimal conditions, an appropriate combination of the composition of the working fluid and the temperature of the heating source is necessary.

Keywords: water-ammonia absorption chillers, waste heat, energy efficiency, natural gas pre-cooling, main gas pipelines.

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DOI: 10.15587/2312-8372.2019.184169

DEVELOPMENT OF IMPLICIT METHOD FOR NUMERICAL MODELING OF TURBOMACHINE BLADE THERMOELASTIC VIBRATIONS

page 41–44

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There was a tendency in recent decades to increase the combustion temperature in gas-turbine engines (GTE). This allows increasing both the efficiency of the engine and the output power. In modern engines, the temperature of the exhaust gas is already significantly higher than the melting temperature of blade material. In this regard, in the design of GTE turbines there is a need to use numerical methods that allow the most reliable modeling of unsteady aerothermoelastic effects. One of the components of the aerothermoelastic problem is to integrate the unsteady equations of thermoelasticity together with the equations of aerodynamics. As these equations must be solved together with a single step in time, implicit numerical integration methods should be preferred. The object of research is the unsteady interaction of thermoelastic vibrations of the turbine blades and gas flow.

This paper presents an implicit numerical method for modeling thermoelastic vibrations of the GTE turbine flow parts, including turbine blades with cooling channels. The method is based on equations of linear thermoelasticity, which are integrated by the finite element method. The investigated volume is divided into cells, forming a calculation grid with hexahedrons with additional nodes. The compute nodes are selected so that one element has 20 nodes. The approximation of the parameters in the element is performed using third-degree polynomials. Time integration is also performed with third-order accuracy.

The results of testing the method on test problems, as well as comparing the results of the vibrations simulation of the standard configuration blades with the results of other authors are shown. The discrepancy of the results does not exceed 0.4 % for the test problem and 0.7 % for the blade vibrations. The obtained results indicate that the presented method can be used for numerical simulation of the unsteady thermoelastic vibrations of the gas-turbine engine flow parts.

Keywords: numerical methods, theory of elasticity, turbine blade dynamics, aerothermoelastics, gas-turbine engine.

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