PESQUISA CIENTÍFICA USANDO O PACOTE DE SOFTWARE DE APLICAÇÃO MATLAB

SCIENTIFIC RESEARCH USING THE APPLICATION SOFTWARE PACKAGE MATLAB

НАУЧНЫЕ ИССЛЕДОВАНИЯ С ИСПОЛЬЗОВАНИЕМ ПАКЕТА ПРИКЛАДНЫХ ПРОГРАММ MATLAB

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Received 01 December 2017; received in revised form 10 May 2018; accepted 15 May 2018

RESUMO

O pacote de aplicativos MATLAB acelera o ritmo de aprendizado, ensino e pesquisa em disciplinas de engenharia e ciências, ajudando a preparar os alunos para uma carreira de sucesso no setor porque é amplamente utilizado para pesquisa e desenvolvimento. Ele recebeu uma ampla aplicação em setores como automação aeroespacial, automotiva, de comunicação e industrial. O conceito de design orientado a modelo é baseado na modelagem de sistemas de alto nível. Isso nos permite desenvolver um modelo baseado em tarefas e especificações técnicas, projetar sistemas usando modelagem de simulação, gerar código automaticamente e também testar e verificar modelos em etapas, do projeto à implementação. Assim, os professores têm a oportunidade de educar os alunos sobre o entendimento da física dos componentes do sistema, sua interação e o comportamento dos sistemas em geral, e tudo isso em um ambiente unificado. No presente artigo, as principais vantagens, interfaces de programas aplicativos MATLAB são apresentados. Os resultados da pesquisa científica de autores utilizando MATLAB - investigação de frequências naturais e parâmetros de amortecimento de molas tubulares de medida no meio viscoso, bem como oscilações de torção dos eixos da unidade de bomba são apresentados. O efeito das características geométricas de molas tubulares nas frequências naturais de oscilações e parâmetros de atenuação é investigado. Usando o pacote MATLAB, foi desenvolvida uma técnica para calcular as tensões associadas à torção dos eixos das unidades de bombeamento.

Palavras-chave: MATLAB, mola tubular manométrica, oscilações, oscilações do rotor da unidade de bomba.

ABSTRACT

The MATLAB application package accelerates the pace of learning, teaching, and research in engineering disciplines and science, helping to prepare students for a successful career in the industry because it is widely used for research and development. It has received a wide application in such industries as aerospace, automotive, communication, and industrial automation. The concept of model-oriented design is based on the modeling of high-level systems. This allows us to develop a model based on technical tasks and specifications, to design systems using simulation modeling, to automatically generate code, and also test and verify models at stages from project to implementation. Thus, teachers get the opportunity to educate students about the understanding of the system components physics, their interaction and the behavior of systems in general, and all this in a unified environment. In the paper, the main advantages, interfaces of MATLAB application programs are presented. The results of scientific research of authors using MATLAB - investigation of natural frequencies and damping parameters of gauge tubular springs in the viscous medium as well as torsional oscillations of the pump unit shafts are presented. The effect of the geometric characteristics of gauge

tubular springs on the natural frequencies of oscillations and attenuation parameters is investigated. Using the MATLAB package, a technique has been developed for calculating the stresses associated with the torsion of the pumping unit shafts.

Keywords: *MATLAB, manometric tubular spring, oscillations, rotor oscillations of the pump unit.*

АННОТАЦИЯ

Пакет приложений MATLAB ускоряет темпы обучения, преподавания и исследований в области инженерных дисциплин и науки, помогая подготовить студентов к успешной карьере в отрасли, потому что он широко используется для исследований и разработок. Он получил широкое применение в таких отраслях, как аэрокосмической, автомобильной, коммуникационной и промышленной автоматизации. Концепция модельно-ориентированного проектирования основана на моделировании высокоуровневых систем. Это позволяет нам разработать модель, основанную на технических задачах и спецификациях, для проектирования систем с использованием имитационного моделирования, автоматической генерации кода, а также тестирования и проверки моделей на этапах от проекта к реализации. Таким образом, преподаватели получают возможность обучать студентов пониманию физики компонентов системы, их взаимодействию и поведению систем в целом, и все это в единой среде. В статье представлены основные преимущества, интерфейсы прикладных программ MATLAB. Приводятся результаты научных исследований авторов с использованием MATLAB – исследование собственных частот и параметров затухания калибровочных трубчатых пружин в вязкой среде, а также крутильных колебаний валов насосного агрегата. Исследуется влияние геометрических характеристик калибровочных трубчатых пружин на собственные частоты колебаний и параметры затухания. Используя пакет MATLAB, была разработана методика расчета напряжений, связанных с кручением валов насосных агрегатов.

Ключевые слова: *MATLAB, манометрическая трубчатая пружина, колебания, колебания ротора насосного агрегата.*

INTRODUCTION

The MATLAB (Alekseev and Chesnokova, 2006) software package is widely used throughout the world for solving problems related to matrix calculations. The name of the package is formed by a reduction from MATrixLABoratory (matrix laboratory). Operations and commands in MATLAB are quite natural and analogous to mathematical formulas on paper. MATLAB was created as a software package which implements the most efficient computational algorithms of linear algebra. It is organized in such a way that the user has the opportunity to apply the usual mathematical language.

MATLAB provides many methods for data analyzing, algorithms developing and models creating. MATLAB includes mathematical functions for engineering and scientific operations. Built-in mathematical functions use processor-optimized libraries designed to accelerate the vector and matrix calculations. MATLAB extensions provide specialized functionality in such areas as statistics, optimization, signal processing and machine learning.

Using MATLAB, you can write programs and algorithms faster than in traditional programming languages, because there is no need for such low-level organizational operations as declaring variables, defining types and allocating memory. In many cases, switching to vector and matrix operations eliminates the need for cycles. As a result, a single MATLAB code line can often replace several C/C++ code lines. The MATLAB interface is shown in Figure 1.

In addition to the core which implements computational algorithms for general purpose, the MATLAB package implements several dozens, the so-called Toolbox (libraries of specialized subprograms), developed to solve various tasks.

Simulink is a graphical simulation environment which allows the building of dynamic models, including discrete, continuous and hybrid, nonlinear and discontinuous systems, using block diagrams in the form of directed graphs.

The interactive environment of Simulink allows the use of ready-made libraries of blocks for simulation of electric, mechanical and hydraulic systems, as well as applying a

developed model-oriented approach in the development of control systems, digital communication facilities, and real-time devices.

Additional Simulink extension packages allow the solving the entire range of tasks from developing a model concept to testing, controlling, code generation and hardware implementation. Simulink is integrated into the MATLAB environment, which allows using the built-in mathematical algorithms, powerful data processing tools, and scientific graphics. The Simulink interface is shown in Figure 2.

MATERIALS AND METHODS

Below the examples of the use of MATLAB in the scientific research of authors are given. With the toughening of working conditions, the intensity and frequency of vibrations of aggregates and installations are growing. Pressure pulsations have a negative effect too. This leads to an increased error in measuring pressure, the wear out of mechanical devices and as a consequence of a breakdown in the technological process. In this regard, it sharply increases in the requirements for vibration protection of sensitive elements of pressure measuring instruments.

Papers (Alekseev and Chesnokova, 2006; Cherentsov *et al.*, 2014; Cherentsov, 2014; Cherentsov *et al.*, 2014b; Pirogov, 2009; Cherentsov *et al.*, 2014a; Pirogov and Cherentsov, 2016; Pirogov *et al.*, 2016a; Pirogov *et al.*, 2016b) are devoted to increasing in the vibration protection for manometric tubular springs, which play the role of sensitive elements of mechanical pressure gauges. After analyzing the existing methods of reducing the vibration, we can conclude that the main methods of protection are tuning from resonant frequencies and vibration damping with liquid.

The manometric tubular spring model is represented as a curved rod oscillating in the plane of curvature of the central axis, which is acted upon by resistance forces proportional to the velocity.

On the basis of the D'Alembert's principle, differential equations of rod motion are compiled and a numerical solution of the system is worked on for which realization a software package is developed. The influence of the geometric characteristics of the manometric tubular springs and the viscosity of the damping liquid on the vibrational motion of the MTP in a viscous

medium is also studied.

RESULTS AND DISCUSSION:

To carry out numerical experiments of numerous characteristics of tubular springs with the help of MATLAB, a software package for the calculation of manometric tubular springs "SPCMTS" was developed. The interface and calculation results are shown in Figure 3.

With the help of this software package, it became possible to design manometric tubular springs with the specified properties, to determine the sensitivity, tractive effort, stresses, that is all that is necessary for the successful operation of the mechanism. In this case, it is possible to determine the properties of tubes with different cross-sectional shapes-elliptical, plane-oval and eight-shaped, and also with a variable cross-section.

To carry out numerical experiments at vibration damping with liquid using MATLAB a software package "Manometer" was developed (Certificate of official registration of the software package 2015615645 RF). The interface is shown in Figure 4.

The software package allows us to determine the natural oscillation frequencies and attenuation parameters, depending on the design dimensions of the spring and the viscosity of the liquid used for damping. The results are shown in Figure 5.

The paper (Pirogov *et al.*, 2017) is devoted to the study of vibrations of pump units.

Vibrations of pump unit is an undesirable phenomenon which contributes to reducing the operational reliability, service life, premature wear out of bearings, and also leads to deformation of rotors, damage to the shell and the foundation. Vibrations mainly arise due to rotating parts. The main driver is the imbalance of the pump unit rotors. The number of failures associated with vibration is very large. Therefore, increasing the vibration protection is an important and urgent problem of our time. One of the methods of protection against vibration is the method of detuning from resonance frequencies. In this case, it is necessary to have the values of free frequencies on pump units and frequencies of the disturbing force. The frequency of the disturbing force is the angular velocity of the rotor turning.

With the help of the Lagrange's equation

of the second type, a technique was developed for determining the free frequencies of torsional vibrations of pump units, and a critical case, the sudden pinching of the shaft, was considered. The resulting shear stresses are determined. It is shown that even at small angular velocities of rotation these voltages can exceed the permissible ones.

CONCLUSION:

MATLAB compared with traditional programming languages (C/C++, Java, Pascal, FORTRAN) allows shortening the time for solving typical tasks by an order of magnitude and greatly simplifies the development of new algorithms.

MATLAB is the foundation of the entire MathWorks family of products and is the main tool for solving a wide range of scientific and applied tasks in such areas as object modeling and control system design, communication system design, signal and image processing, signal measurement and testing, financial modeling, computational biology, etc.

The MATLAB core allows you to work with matrices of real, complex and analytical data types as easily as possible, and with data structures and lookup tables. Using MATLAB, we can analyze data, develop algorithms, create models and applications, and successfully solve complex engineering problems.

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Figure 1. MATLAB interface

Figure 2. Simulink interface

Calculation of a constant-pressure manometer spring

Data for calculation

Poisson's ratio

Elastic modulus - E - (10^6 kgs/sm²)

Working pressure of a spring (kgs/sm²)

Moment of power (kgs*sm) or strength (kgs)

Radius of the longitudinal axis of the spring (mm)

The central angle of the spring (degrees)

The angle of application of external force (degrees)

Wall thickness of spring (mm)

The semimajor axis of the cross section of the spring (mm)

The small semiaxis "b" of the spring cross-section (mm)

Radius of curvature at the end of the semimajor axis (mm)

Small semiaxis "c" of the cross section of the spring (mm)

Show section form

Calculation of static characteristics

Clear

No access

No access

Calculation of frequencies of free oscillations

Calculation of the attenuation parameters

Measurement mode

☒ Free play

☐ Taking into account the current moment

☐ Given the concentrated force

Power compensation mode

☐ Hard fit

☐ Hinged-fixed fastening

☐ Swivel Mounting

Entering Section Parameters

☒ absolute units of measure

☐ relative units of measure

Exit

Figure 3. The interface of the main calculation module

Calculation of attenuation parameters

Data for calculation

Poisson's ratio

Elastic modulus - E - (10^6 kgs/sm²)

Working pressure of a spring (kgs/sm²)

Density of spring material (kg/m³)

Radius of the longitudinal axis

The central angle of the spring

Spring wall thickness (mm)

The semimajor axis of the cross section of the spring

The small semiaxis "b" of the spring cross-section (mm)

Radius of curvature at the end of the semimajor axis

The small semiaxis "c" of the cross section of the

Dynamic viscosity of a liquid (Pa s)

Width of bulb (mm)

Calculation

Section building

Clear Results

Parameters for calculation

Specify an interval for frequency search, Hz

Initial value

Final value

Initial deviation of spring end, mm

Section shape

Graph of amplitude of oscillations

Figure 4. The interface of the "Manometer" software package

Figure 5. Results of calculating the frequencies of the fundamental oscillations of manometric tubular springs: a) effect of wall thickness; b) influence of ratio of the semi-axes; c) effect of the central angle; d) influence of the radius