Institute of Machine Design Fundamentals
Warsaw University of Technology

Department of Computer Aided Systems
Lviv Polytechnic National University

КАФЕДРА САПР
COMPUTER AIDED SYSTEMS

XXV Polish - Ukrainian Conference on "CAD in Machinery Design - Implementation and Educational Problems"

Bielsko Biała , October 20 – 21, 2017

BOOK OF ABSTRACTS

Bielsko Biała, October 2017

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Contens:

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XXV POLISH-UKRAINIAN CONFERENCE
CAD IN MACHINERY DESIGN – CADMD 2017

Bielsko Biała, October, 2017

Paweł Chodkiewicz Faculty of Production Engineering
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DEM ANALYSIS OF VPP DAMPER

Authors want to present a new way of analysis and modelling of the Vacuum Packed Particle damper with the use of Discrete Element Method. Such structures are composed on the basis of loose granular materials encapsulated in a hermetic space. Initially, the granular system behaves like a classical plastic mass. When the internal pressure is pumped out of the system, what was baggy bulk transforms into the solid (semisolid) state. This particular ability could be useful in some specific applications.

In previous works of the authors Vacuum Packed Particles were described by fenomenological models such as Gubanov or Gamota-Filisko. Those formulas do not take into consideration a micro behaviour of granular particles inside the damper or granular and encapsulation interactions.

In this paper the authors provide the new DEM model for the Vacuum Packed Particles damper. The first step is to develop a model of an encapsulation including special boundary conditions (pressure) For the modelling process the YADE DEM software was used. YADE DEM is an extensible open-source framework for discrete numerical models, focused on Discrete Element Method. Authors developed a special plugin for the model that enables modeling the response of Vacuum Packed Particles on the external loading. Acquired numerical results are presented and discussed.

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DESIGN OF NEW FLAT BELTS

1. Introduction

Modern flat belts can meet the highest demands of modern machinery. Machine drives use the highest speeds, up to the highest power levels in the toughest conditions. They are used in parallel presses for continuous pressing. Presses for wood boards or plastics are extremely disadvantageous to the environment. Designing new flat belts is related to the challenges of machine builders and the new technological capabilities of material manufacturers. Modern flat belts can perform many functions in mechanical and mechatronic systems.

2. Coupling between belt and pulley

While creating a new flat belts, designer have to return to the basic operation of these gears and the belt- pulley coupling model. In his work – Euler describe basic model of the friction coupling, and although this problem was later addressed by many authors. The development of the Euler idea, allows for the understanding of the phenomena occurring in the flat belt transmission gears. In the actual transmission, indicate the phenomena between the belt and the pulley and between the belt material and the cord.

3. Flat belt construction

In the flat belts designs, there is a large group of solutions. They can be divided into: solid, textile and composite. Solid materials include Polyamide, Polyurethane, Polyester, and Steel and other metal alloys. Fiber materials are mainly fabrics and cables made of mineral, synthetic materials and metal alloys. Composite support layer is most

commonly combination of previously mentioned materials. The new warp types are aimed at improving their mechanical properties, and the "unstretched" cord is used to get closer to the Euler model. At the same time it has to be flexible so that the belt can work on wheels of small diameters.

4. Conclusion

In modern flat belts are additionally placed elements allowing precise control of the work of the belt and system. There are elements in the belts that work with detectors and readers and signal wires. Flat belts continue to address many design challenges in machine construction, in the area of drives and conveyors, but also in regulation and control systems.

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DESIGN OF NEW FLAT BELTS

Summary

The development of material engineering has contributed to the development of new materials that can be used in the solutions of flat belts. The paper presents examples of such materials and problems that they have solved. A wide range of applications, from driving belts, through conveyor to control systems, requires a new approach to the design of these belts. The basics of flat belt mechanics are based on the Euler and Couloumb equations and are also the basis for designing new gears design. Choosing the right carrier layer affects the state of stress and deformation in the tendons. The quality of the surface affects the friction pair the belt- pulley, the belt - the material being transported and the volumetric wear. Wide availability of polymeric materials and composite fibers allows the design of specialized belts for a specific application

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PHYSICAL PRINCIPLES OF OPTIMIZATION OF THE STATIC REGIME OF A CANTILEVER TYPE POWER-EFFECT SENSOR WITH A CONSTANT RECTANGULAR CROSS-SECTION

1. Introduction

Cantilever beam is a basic element of modern sensors of external force. The physical principle of the operation of the sensors is based on the effect of bending deformation of the cantilever under the action of the applied force to its free end, which is based on the work of biosensors [1] and probes for atomic force microscopy [2].

Figure 1 shows the calculation scheme of the power sensor in the form of a cantilever of a rectangular type with a stable cross-section, one end of which is rigidly fixed, and the other is free.

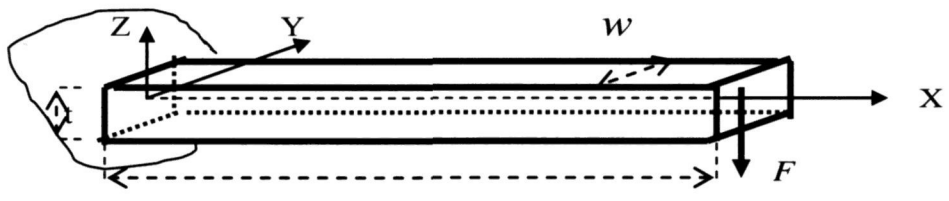

Fig. 1 The calculation scheme of the power sensor in the form of a cantilever of a rectangular type with a stable cross-section

The calculations were performed using method NSGA-II using ES-EA procedures for optimization in Matlab codes. [4]. For calculation the parameters of optimization used: number of population = 100, number of iterations =100. The bisected fronts of Pareto in coordinates $\delta - m$ [5], shown in Fig. 2, a, is presented as a test for comparison in order to confirm the correctness of the conclusions drawn in this paper. As we can see in Fig. 2, b,

in the variations of the geometric parameters of the $0.1\mu m < t < 5\mu m$, the quality of the Pareto-optimization front is high with a uniform distribution of the approximation points by the Cauchy optimization criterion.

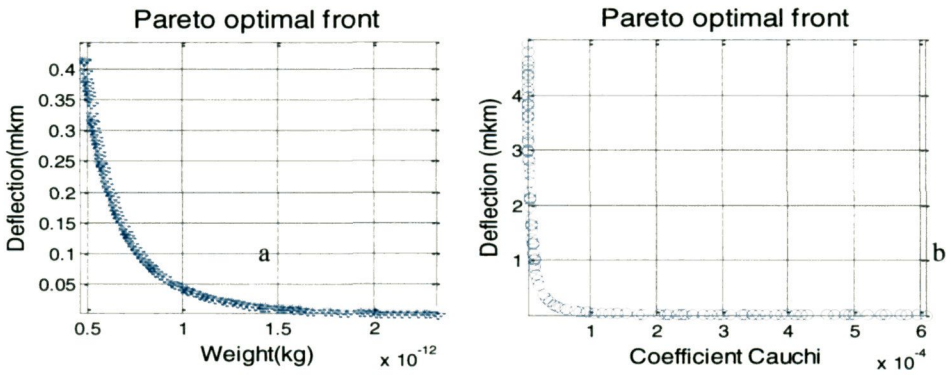

Fig. 2. Bi-objective optimization curve of Pareto compromise design in plane coordinate : deflection-mass (a) and deflection - coefficient Cauchi (b)

2. Bibliography

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PHYSICAL PRINCIPLES OF OPTIMIZATION OF THE STATIC REGIME OF A CANTILEVER TYPE POWER-EFFECT SENSOR WITH A CONSTANT RECTANGULAR CROSS-SECTION

Summary

In this paper an analysis of the physical principles of two-criterion optimization Pareto static mode of operation of power sensors cantilever type of rectangular type with a stable cross-section. The proposed criterion based on the Cauchy number is one of the characteristic numbers of the proportional miniaturization of microsystem technology. It is established that for a rectangular cantilever with a stable cross-section, the value of the Cauchy does not depend on the width of the micro-console and the material from which it is made.

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WEAR EVALUATION STUDY OF THE MULTIPLE GROOVED PULLEYS WITH OPTICAL METHOD

1. Introduction

Multiple grooved pulley wear can be evaluated by using two methods, coordinate method and optical method. This paper presents the results of the research and the analysis of the geometrical features for this type of pulleys, which was obtained with the ATOS II optical system. In this method the evaluation of wear is made based on the comparison of the manufactured parts or assemblies with superimposing the CAD model and the surface model obtained from digitization [1]. Existing differences can be easily determined by their visualization in the form of a colored map of deviations or profile differences. This method is subject to a methodological error, which is a result of the accuracy of the scan and the correctness of the model's fit. Optical techniques can be used to determine the accuracy of the geometric features for products made with any shaping technique (machining, plastic processing, incremental methods, etc.).

2. Research results

The operation of the ATOS II system is based on the triangulation principle. The measurement procedure is made by determining the coordinates of the measuring point based on the known position of the cameras. Example measurements of the pulleys are shown in Fig. 1.

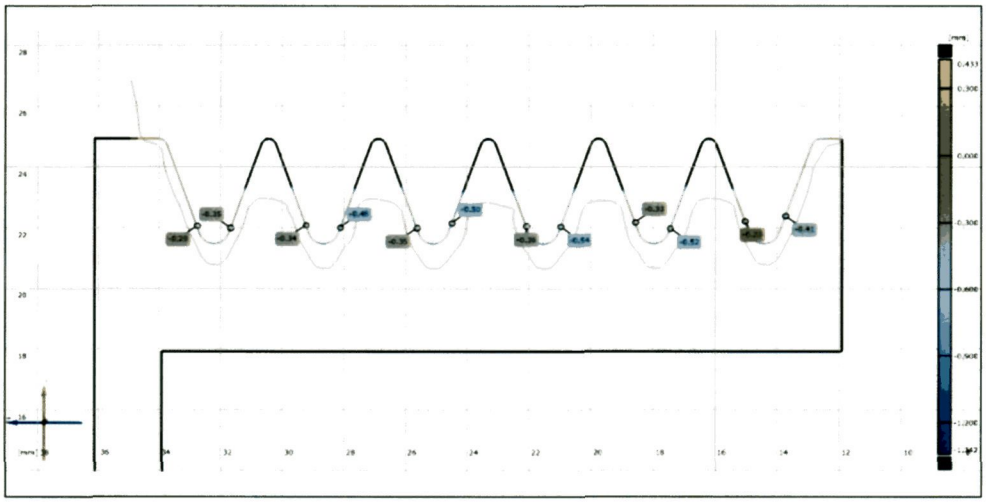

Fig. 1 Differences in dimensions between the CAD model and the used pulley

For the optical method and the contact method described in [2], four inspection sections are perpendicular to the axis of rotation of the pulley model. An important step in verifying the accuracy of geometric features of pulleys is the selection of the evaluation criteria.

3. Bibliography

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WEAR EVALUATION STUDY OF THE MULTIPLE GROOVED PULLEYS WITH OPTICAL METHOD

Summary

The results of the evaluation of the geometric features for new and abandoned wheeled pulleys were presented. The ATOS II optical system was used. The results will be useful for engineers, which design the strand drives as well as for those that deal with the exploitations of vehicles.

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CAD IN MACHINERY DESIGN – CADMD 2017

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DESIGN AND MANUFACTURE OF THE CASING FOR RADIO ELECTRONIC EQUIPMENT

1. Introduction

The casing of electronic equipment is a plastic or cast aluminum housing designed for use in measuring technology, household and industrial electronics. The electronics housing, generally sealed, can be changed to IP54 and IP65 specification, in addition, it can also have a transparent plastic cover.

The most profitable and high-quality way of producing plastic cases is 3D printing.

As an example, we made a case for the PCB. The process consists of several stages:

1. Construction of 3D model of the product - 3D modeling of the future product.

Designing the model of the desired shell is performed in the 3D editor Blender (fig. 1). The model can also be designed in other editors: 3D Studio Max, AutoCAD, Solidworks. Blender was elected through a number of advantages: a free license, a high speed painting, a small size.

We measured the size of the PCB and manufactured the model taking into account the possible error in printing. The distance between the walls of the body is more than 0.5 mm. Also in the right places were holes for fixing the board.

2. Correction of the parameters of the three-dimensional model, sending the model to print. When exporting a model from a 3D editor to the FlashPrint application (fig. 2), errors can occur: the model does not lie on the platform, the wrong dimensions. After fixing them, the next step is to check for hanging parts (fig 3) and create support (fig. 4): automatically or manually. Set the parameters: the type of plastic, the thickness of the layer, the type and percentage of filling and send the model to print

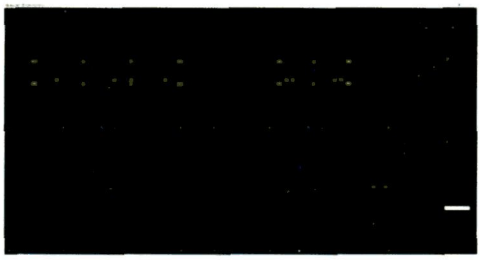
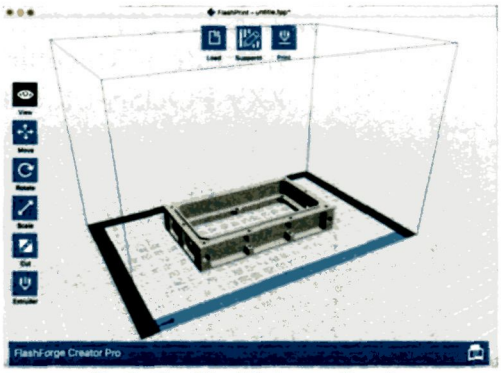
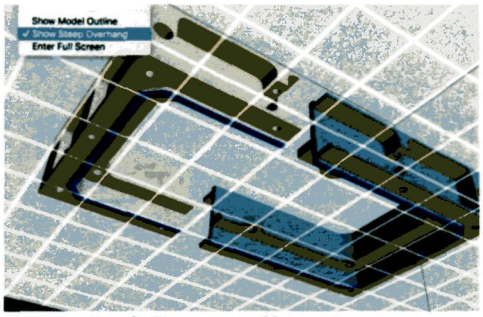


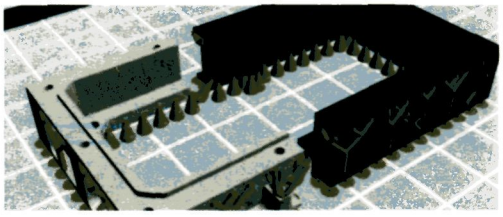
Fig. 1. The modeling of the casing



Pic 2. The FlashPrint application



Pic 3. Presence of hinged parts



Pic. 4 Creating support

3. Post-processing of the finished product. After printing, the model needs to be cleaned of unnecessary support elements.

3. Bibliography

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DESIGN AND MANUFACTURE OF THE CASING FOR RADIO ELECTRONIC EQUIPMENT

Summary

In the process of work, we realized that the manufacture of housings for radio electric devices using the 3D printing method has its advantages:

- Short duration of preparatory work;
- Low cost;
- High quality of the product.

But this method has its drawbacks:

- Limit on dimensions;
- Constraint in the construction.

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DESIGN AND DEVELOPMENT OF OMNIDIRECTIONAL SOUND SOURCE

1. Introduction

For acoustic excitation of apartment of omnidirectional source of noise can be different form. But most popular are two forms, each of that has the advantages and defects. It is a spherical source and source with a dispersive cone.

2. Practical part

The orientation of sound of the spherical source usually presented as a dodecahedron is near to spherical. A source is optimal for measuring of time of reverberation, including in apartments with penetrating noise.

The second form of omnidirectional sound source is folded all from one the dynamics, unlike 12 in spherical, and to the dispersing cone. But the orientation of this source is even only inplane to the dispersing cone basis. Maximal rejection of non-directional - no ±more 2dB in a frequency range 100 - 12500 Hz.There is the optimal for measuring of sound-proofing ceiling high-performance sound-proofing in area of high-frequencies, for example in the inhabited apartments.

We chose the spherical form of sound source, in fact it has the best orientation and does not need powerful loud speakers. To attain the necessary level of volume easier by means of 12 loud speakers, than by means of one, the sound-waves of that will disperse.

The chosen form is modelled by means of package for creation of three-dimensional graphic arts of Blender. It software was chosen through the turn of advantages : small size, high-rate of draw in detail, license of GNU GPL and other.

How a form shows a soba a dodecahedron - correct polyhedron made from twelve correct pentagons, it was needed gone into detail to model one verge only.

The side of pentagon equals a 225 mm Thickness of verge is a 15 mm opening Diameter under a dynamics is a 154 mm For that, to connect all parties together and to avoid gaps, it is done chamfer under the corner of 122°.

A model is successfully projected and on her basis the real object is built by means of the use of technology of cutting of arboreal material. The finished sound source is represented on Fig. 1.

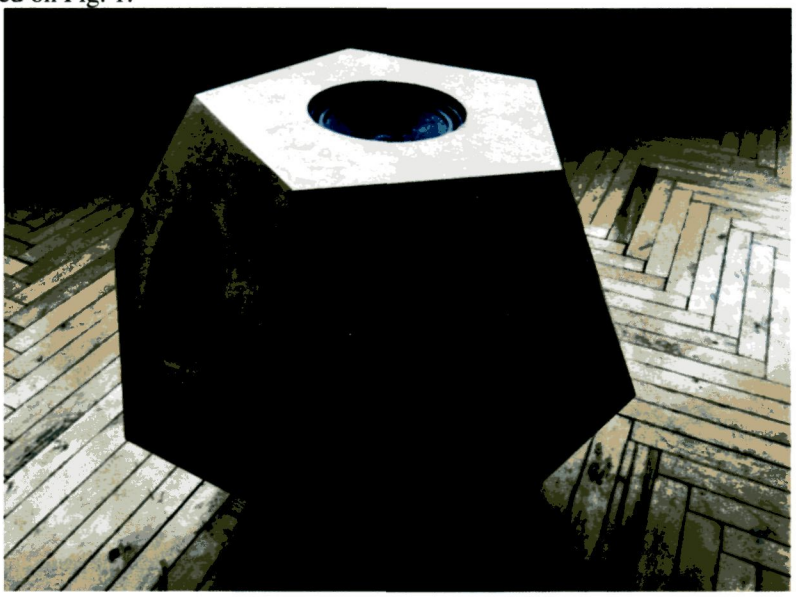

Fig. 1 Omnidirectional sound source

3. Bibliography

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DESIGN AND DEVELOPMENT OF OMNIDIRECTIONAL SOUND SOURCE

Summary

For the construction of model of construction for research of reverberation and sound-proofing in apartments, among ten of the design programs, a package was select for creation of three-dimensional graphic arts of Blender, that fully answers all criteria for the valuable construction of model. A model is successfully projected and on her basis the real object is built.

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PREVENTING CONFLICTS IN THE SOFTWARE DEVELOPMENT PROCESS

1. Introduction

Scrum is a popular agile software development model for managing product development. Scrum provides more interaction with the end-users and allows to respond to new user needs. Despite all the benefits, using Scrum leads to the poor implementation of the basic software architecture. Because of this, developers are constantly confronted with conflicts in the logic of the program (fig. 1).

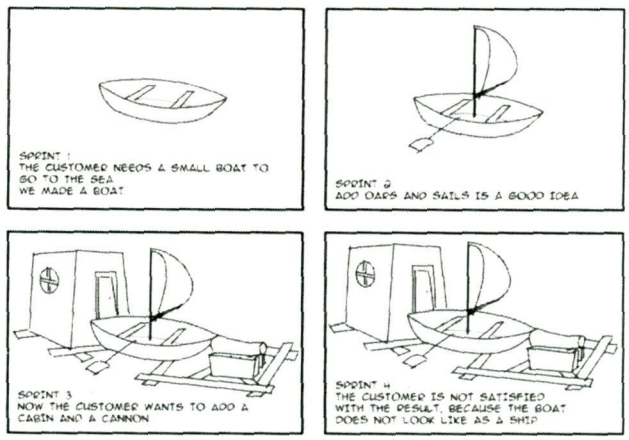

Fig. 1. Using Scrum to build a ship

2. Analyzing conflicts in the software development process using the Scrum methodology and suggesting to prevent conflicts

To analyze the potential conflicts and problems, we took the team of 10 people: 4 backend developers, 1 frontend developer, 2 testers, 3 managers.

Sprint volume distributed as follows: 2/3 of the time allocated to the tasks, remaining time - to unintended risks. The duration of the sprint was 2 weeks. Each sprint and each task had a separate branch in the version control system (VCS). At first, the task branches were merged with the test string, and tested on it. Successfully tested tasks were merged with the sprint branch. At the end of the sprint, the sprint branch was retested and then merged with the default branch.

Problems arose at the end of the sprint when the accumulated corrections and new functionality appeared. For example, when merging branches, conflicts often appeared and they had to be solved manually. Several times, the automatic resolution of conflicts led to the complete collapse of some modules.

The main reasons for the problems were the following: large branches, large number of branches, fast fix, tasks that do not fit the goal of the sprint, bad description of tasks.

Based on the description of the task and knowledge of the software structure, the developer evaluates the execution time, and decides whether to include this task in the sprint.

Tasks with similar descriptions will relate to the same parts of the program. Having analyzed the description of the tasks, they can be clustered. This will allow you to quickly create a new sprint and correctly distribute tasks between developers. Preliminary analysis of the description also helps avoid duplication of tasks.

As a result of the sprint performance, the module can be taught to understand the structure of a software product and evaluate future tasks. To do this, as a training set, you can use the description of the task, the changes that led to its implementation and the theoretical and real time of execution.

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PREVENTING CONFLICTS IN THE SOFTWARE DEVELOPMENT PROCESS

Summary

In the process of software development, it is impossible to completely avoid conflicts. New requirements of the users make the product adapt to the needs of the market. Using the Scrum model allows you to respond quickly to such changes, so it is most prone to conflict generation. The most effective way to avoid conflicts is to provide a timely warning about them.

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THE METHOD OF SEQUENTIAL CLUSTERING FOR PREDICTING RECOMMENDATIONS

1. Introduction

There are subject areas in which there is a need to predict recommendations for user communities. It can be a selection of television programs for the community of users, the choice of radio programs for the staff at the fitness center, the choice of the tourist route for groups of users. When solving such problems, it is necessary to integrate the interests of community members in the interest of the community as a whole. This process requires the solution of two classes of tasks: 1) the allocation of user communities, 2) prediction of objects for the community of users. Systems for predicting recommendations for user groups can solve the problem of predicting recommendations for a new user. There is no profile vector for the new user or it contains a very small number of ratings.

2. The method of sequential clustering for predicting recommendations

In the developed method, it is proposed to isolate user groups using a sequential two-stage clustering.

At the first stage, groups of users are distinguished, which are similar in their demographic characteristics. Each user is characterized by a demographic profile vector, which contains the following categorical parameters: age, gender, occupation, education. To select user groups, use the k-mod categorization clustering method. At the second stage, clustering by the similarity of the numerical vectors of user profiles is carried out in each of the groups identified by demographic characteristics. To do this, a modified method of k-means is used, which in automatic mode allows selecting the necessary optimal number of clusters and breaking objects into clusters with clustering accuracy control. Each received

cluster is considered as a separate group of users, for which a forecast of recommendations is made. The process of forecasting recommendations for a new user has two steps:

1. Based on the demographic characteristics of the new user, it refers to a specific demographic group (demographic cluster).
2. If the rating vector of the profile is empty, it predicts objects based on the averaged profile vectors of all group members.
3. If the rating vector of the profile contains estimates, it refers to a certain rating group and offers items that take into account the interests of all members of the group.

For the prediction of objects in a group, a method is used that combines the additive and multiplicative utility of objects in a group. The proposed method solves the problem of sparseness of the user-item matrix, the problem of inaccuracy in calculating the similarity coefficients between the user profile vectors, the scalability problem, the problem of the new user.

3. Bibliography

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THE METHOD OF SEQUENTIAL CLUSTERING FOR PREDICTING RECOMMENDATIONS

Summary

A method of sequential clustering is proposed for prediction of recommendations. The method involves two stages of clustering. At the first stage, clustering of users according to demographic characteristics is carried out. At the second stage, communities of users with similar interests are singled out. For the prediction of objects in a group, a method is used that combines the additive and multiplicative utility of objects in a group.

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2D NUMERICAL MODEL FOR DETERMINATION OF THE TRANSIENT TEMPERATURE FIELD DURING CONTINUOUS-DRIVE FRICTION WELDING

1. Introduction

Friction welding is a widely used solid-state joining process. Metallic and nonmetallic materials with different thermomechanical properties can be welded. One of the most effective numerical method for structural and thermal problems is the finite element (FE) method. Several studies have so far been made to investigate the thermal problem of friction welding. In this paper axisymmetric FE model of the continuous-drive friction welding (CDFW) has been developed to analyse a temperature field.

2. Problem statement

A friction stage of CDFW process is considered (Fig. 1). Assembly of two cylindrical parts by rotational friction when applying a compression, constant pressure p_0 generates heat at the contact zone. One part is stationary while the second is rotating with constant value ω_0 in predetermined time t_s. After this stage the rotation is stopped and final forging pressure is applied to make the weld. It is assumed that the properties of materials and coefficient of friction are temperature-dependent.

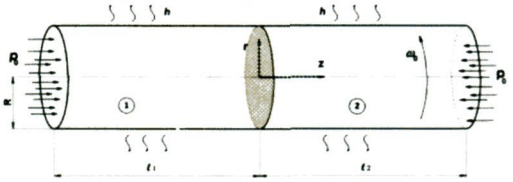

Fig. 1. Schematic diagram of frictional system in CDFW process

3. Numerical analysis

Simulation of frictional heating in a couple during a friction process with parameters: f_0=0.158, p_0=75 MPa, ω_0 =146.6 rad/s (Bouarroudj et al., 2017), h=40 W/m^{2}K, t_s=8 s using FE based software (COMSOL Multiphysics v. 5.2a) was carried out. The calculations were performed for two specimens of radius R=6 mm and length l =30 mm each, made of steel AISI 1040 (K_0=52 W/(mK), c_0=479 J/(kgK), ρ_0=7860 kg/m^3).

The analysis was carried out for four variants: 1) at temperature-dependent coefficient of friction f and thermophysical material properties K, c, ρ; 2) at temperature-dependent coefficient of friction f and constant thermophysical material properties $K = K_0, c = c_0, \rho = \rho_0$; 3) at constant coefficient of friction f_m and temperature-dependent thermophysical material properties K, c, ρ; 4) at constant coefficient of friction f_m and constant thermophysical material properties $K = K_0, c = c_0, \rho = \rho_0$, where f_m = 0.328 is an average value of the coefficient of friction obtained based on its temperature dependence.

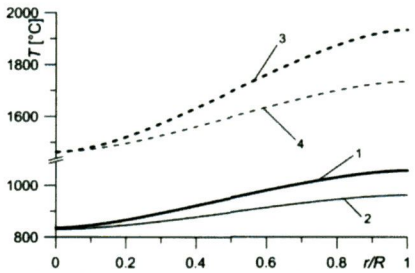

Fig. 2. Distributions of the calculated temperature in radial direction at the end of the process ($t=t_s$); numbers 1-4 correspond with mentioned above variants of computations

4. Conclusion

The carried out numerical calculations revealed that taking into account dependence of the coefficient of friction on temperature causes significant decrease in maximum temperature compared to corresponding values calculated at constant value of the coefficient of friction (Fig. 2).

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2D NUMERICAL MODEL FOR DETERMINATION OF THE TRANSIENT TEMPERATURE FIELD DURING CDFW

Summary

The axisymmetric nonlinear thermal model of frictional heating during continuous-drive friction welding is proposed. The solution of the corresponding boundary-value problem of heat conduction with allowance for frictional heating for two cylinders of finite length was obtained by the finite element method (COMSOL Multiphysics).

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Bielsko Biała, October, 2017

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HEAVE COMPENSATION SYSTEMS – MOTION CONTROL IN OFFSHORE INSTALLATIONS

During the past few decades due to development of industries based on a usage of raw materials such gas, fuel or petroleum, the offshore industry has required a significant development of new technologies and equipment, which might be implemented into the offshore operations carried out under difficult weather conditions and high sea states.

The offshore basic installations are mostly the activities of transshipment or immersing objects between two mediums, which are being in motion relative to each other. The movements of the vessel resulting from sea waves and wind blows lead to high dynamic loads occurring in object lifting slings attached to the crane hook, which are transmitted directly to the structure of a deck crane. To avoid the aforesaid phenomenon, there arises a need to reduce a heave motion of the vessel by applying a heave compensator as a part of a hoisting system. The passive heave compensator is in principle a pure spring damper system, which does not require input of an external energy during its work. The main principle of the PHC system is to store the energy recovered from the external forces influencing the system, in this case – sea waves and then dissipate or reuse the energy later. For analysis purposes the PHC system has been simplified to the second order dynamic mathematical model, where the input and output motions are represented with an amplitude and frequency resulting from the sea waves influencing the submerged object and the vessel.

Application of heave compensators allows to reduce the impact of sea and weather conditions on the difficult process of crossing the splash zone, submerging and seabed landing of the subsea structures. This also ensure safety and reliability in a wide spectrum of sea states, including occurrence of sea currents and also in a weather conditions, including wind speeds. The solution brings many of economic benefits for the offshore industry, which mainly are: increase of productivity through minimizing downtime,

significant costs reduce, improvement of efficiency, increase of lifting and subsea lowering capability, controlled and safe handling of submerged loads. What is more, there are also other benefits that are crucial for design and operation field of the entire hoisting system. These are for example: minimizing the dynamic loads transmitted to the crane structure, reduce the velocity of the crane tip and the seabed landing velocity, neutralizing the risk of loosening on the rope of the lifting set while passing through the splash zone – slack cable, the possibility of eliminating or even avoiding the resonance.

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NUMERICAL INVESTIGATION OF VIBRATION OF THE VEHICLE EQUIPPED WITH MR DAMPERS

1. Introduction

In this paper vibrations of the vehicle equipped with controlled dampers magneto-rheological (MR) type are examined.

The presented subject matter of this work comprises semi-active systems of vibration damping in mechanical systems. Development of active and semi-active systems is closely related to development of electronic control systems. These solutions made possible building mechanical systems in which change in the damping force takes place within a few milliseconds. These properties contributed to application of the semi-active systems of vibration damping in vehicles, machines, and building constructions [1-4]. The dampers controlled by means of an electromagnetic valve are characterised by the simple design which is their essential advantage.

The presented vibrations equation and the algorithm determining the control signal of the damper, so that the acceleration of the vehicle body is minimal at any time. There is an example of a vehicle model and the simulation results showing the effect of vibration dampers to control the acceleration of the body, and the variations of the wheel vertical forces. In the present model of the vehicle it is assumed that the vibrations of the vehicle are excited with the witness of the road and slow-changing load inertia arising during vehicle movement.

The selected results of vehicle vibration simulations during transient high speed motion are presented. The presented simulation results provide a comparison of vehicle vibration with controlled MR dampers and vehicle classical dampers. To evaluate vibration

of the vehicles there are two criterions selected: body vertical accelerations and variation of the value of vertical wheel forces. These investigations are carried out in Matlab/Simulink software.

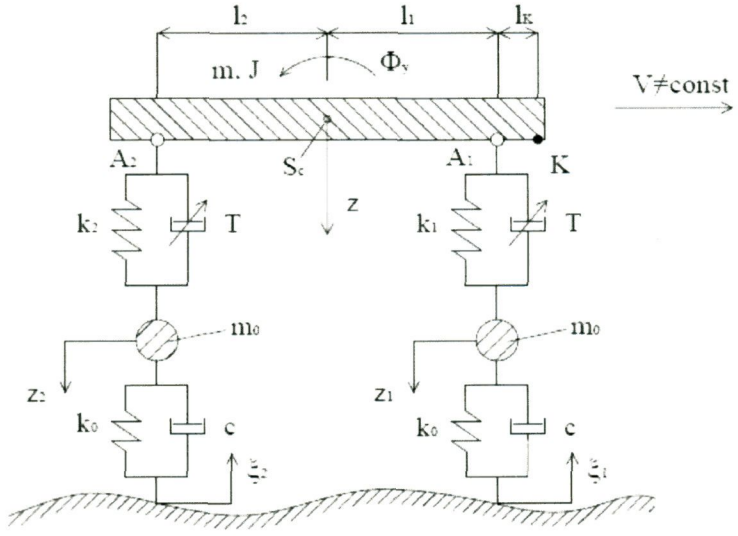

Fig. 1. Schematic diagram of mechanical system, which was adopted as vehicle model; Sc - is the center of mass

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Bielsko Biała, October, 2017

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THE CONTROL SYSTEM FOR THE TRAINING MODEL OF CNC MACHINE TOOL

1. Introduction

The modern high-performance manufacturing methods are based on the use of CAD/CAE/CAM systems that ensure the integration of design and manufacturing processes. For studying, researching and mastering the skills of practical use of integrated CAD/CAE/CAM systems, the CAD Department of the Lviv Polytechnic National University is equipped with 3-D printers, a CNC machine tool and specialized software for computer-aided design. However, the modern industrial CNC machine tools are completed software and hardware complexes and are not suitable for experimental research in the learning process. Therefore, the task of creating the training model of a CNC machine tool to study the principles of its construction, and, especially, to the development of its control system, is actual. In this work, the control system for the developed training model of a CNC machine tool is proposed. It is based on the interpretation of control data, obtained by means of CAD in the process of technological preparation of production.

2. Development of the control system for a model of CNC machine tool

The proposed structure of the control system for the training model of the CNC machine tool is presented in Fig. 1. To move the working tool by coordinates XY the stepper motors are used, and to move the tool along the Z-axis the solenoids are applied.

The structure of a four-byte control word, which is used by the interpreter of the model CNC machine tool, is presented in Fig. 2.

Where: +X = 1 (-X = 1) - step to the right (to the left) (if +X = 1, then -X = 0; if -X = 1, then +X = 0; if +X=0 and -X=0 then step is absent);
+ Y = 1 (-Y = 1) - step forward (back);
+ Z = 1 (-Z = 1) - step down (up) (lowering and raising of the working tool);
+ U = 1 (- U = 1) - turn on (deactivate) the working tool;
N - number of steps, performed in a loop;

T - duration of the period between steps (in msec).

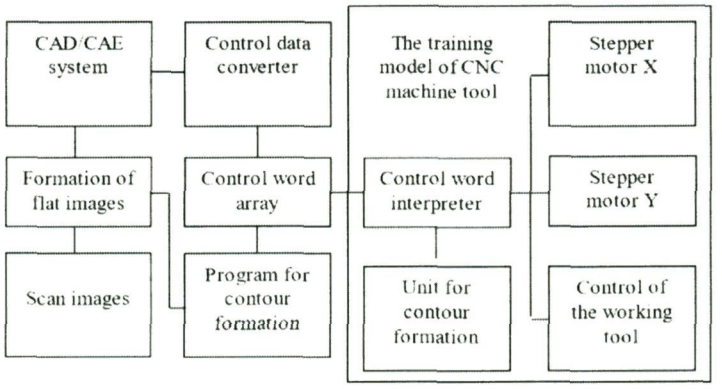

Fig. 2. The structure of the control system for the model of the CNC machine tool

+X	-X	+Y	-Y	+Z	-Z	+U	-U	N	T
1 bite				2 bite				3 bite	4 bite

Fig.3. The structure of a four-byte control word

In the work also foresees the software implementation of this method, based on the encoded image of the detail. In this case, the equidistant line and the coordinates of displacements for control words are determined at the stage of technological preparation of production.

THE CONTROL SYSTEM FOR THE TRAINING MODEL OF CNC MACHINE TOOL

Summary

The control system for the model of the CNC machine tool is presented in this paper. It focuses on the study of the features of CAD / CAM systems building in the educational process. The developed control scheme for stepper motors on the basis of programmable ROM provides reprogramming, reducing the number of elements and high speed. The software and hardware implementation of the proposed method for determining the equidistant trajectories of the working tool movement is realized

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COMPARISON OF METHODS FOR MEASURING REVERBERATION TIME

1. Introduction

Reverberation time is one of the important criteria that determines the acoustic quality of any room. According to ISO 3741: 2010 [1], reverberation time is the time required to reduce the averaged volume of sound energy density in a closed environment at 10 ^ (n / 10) times, that is, at n dB after switching off the noise source. Nowadays there are a lot of systems for determining the reverberation time based on the analysis of the registered impulsive response of the room to excitation impulse noise, but they only allow to process one audio file. To conduct research to improve methods for determining reverb time scientists need to handle large amounts of files. The task to develop a system that allows automating the process of batch processing of a large number of audio files is important, and for this purpose it is necessary to choose the optimal method or to improve the existing ones for the purpose of implementation in the system being developed.

2. Registering a room response to pulse noise

At each measuring point, the maximum sound pressure level in dB is specified. As a source of impulse noise, petards were used. Shots were carried out on the spot where the lecturer is usually placed during the lecture. The microphone was placed at a height of 1.2 m from the floor where the ears of the listeners sitting at the desk are located. During the experiments the impulse source generated a peak sound pressure level in which the initial level of the downturn curve was in all cases greater than 45 dB from the background noise level in the corresponding band of frequencies when measuring T30 [2].

The subsystem for analyzing the registered audio files with the response of the room to impulse excitation was developed taking into account all the requirements of the standard ISO 3382-2 [2].

A subsystem has been developed that allows to investigate the accuracy of methods of inverse integration and least squares on experimental data. Based on the results of the research, the method of least squares was improved by using the pre-processing of the signal by the method of the alternating average. However, even the improvements made it impossible to obtain the accuracy of the Schroeder method in relation to the Dirac system, which can be explained by the fact that the Dirac system also uses the Schroeder method. The mathematical and software of the subsystem of automatic estimation of acoustics of premises by impulse method has been developed.

3. Bibliography

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COMPARISON OF METHODS FOR MEASURING REVERBERATION TIME

Summary

The article presents the results of an experimental evaluation of the reverberation time of the lecture auditorium in the Lviv Polytechnic National University. For their further analysis a sub-system of batch processing of audio files with a registered response of the room for excited impulse noise has been developed. To determine the bypass signal, Schroeder's method was used and the least squares method was improved by pre-processing of the signal using the MM method. The influence of the number of neighboring points of the MM method on the accuracy of the time of reverberation method by the least squares method is investigated. A comparison of the Schroeder method and the least squares method was made, which made it possible to establish that Schroeder method is more precise. The average error of this method for 6 experiments against the Dirac system was 0.02 sec, whereas for the least squares method it was 0.06 seconds. The developed subsystem of the batch analysis of the registered response of the premises for pulsed noise made it possible to increase the speed and efficiency of processing the results of experiments.

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OBJECT SEMANTIC MODEL FOR LIFE CYCLEMODEL "JUMP"

1. Introduction

In the paper semantic model of base interactions between objects for lifecycle model "Jump" [1] is proposed.

2. Semantic Model Development

Lifecycle model "Jump" [1] ($\aleph$) may be represented as a following tuple on the basis of system analysis classical theory.

$$\aleph = \langle P(\Im, \Re, H), K, L \rangle, \tag{1}$$

where: $P(\Im, \Re, H)$ – set of rules and structured data about a simulation object;

P – simulation object;

$\Im$ – set of basic concepts for simulation object;

$\Re$ – set of relations between the basic concepts of the model;

H – set of description and interpretation of basic concepts and relations functions;

K – set of integrity constraints;

L – data modeling presentation language.

Let us represent set $\Im$ in next way:

$$\Im = \{Form, ParameterForm, ValueForm, EventForm, LinguisticVariable, ElementForm, ParameterElement, ValueElement, EventElement, ContainerSolutions\} \tag{2}$$

where: Form – some isolated and uniquely identified part of the subject area;

ParameterForm – set of types and methods of subject area properties description;

ValueForm – value assigned to the type and method of subject area properties description;

EventForm – event or events group which can occur with subject area in specified time;

LinguisticVariable – one named logical description of actions when events occur;

ElementForm – element or elements group of (subclass of the object) of a visual representation of user interaction and simulated software;

ParameterElement – types and methods of describing the properties of elements, single or grouped by some characteristics and identified by a name;

ValueElement – value assigned to the type and method of element properties description;

EventElement – event or elements group which can occur with an element that performs a certain function at some point or time interval;

ContainerSolutions – a named description of the reactions when an event or events group occurs at a certain point in time by an element (elements group) or subject area.

Let us represent expression (2) as a semantic model on Fig.1. The elements are located in the rectangles, and the arrows show the relationship between them.

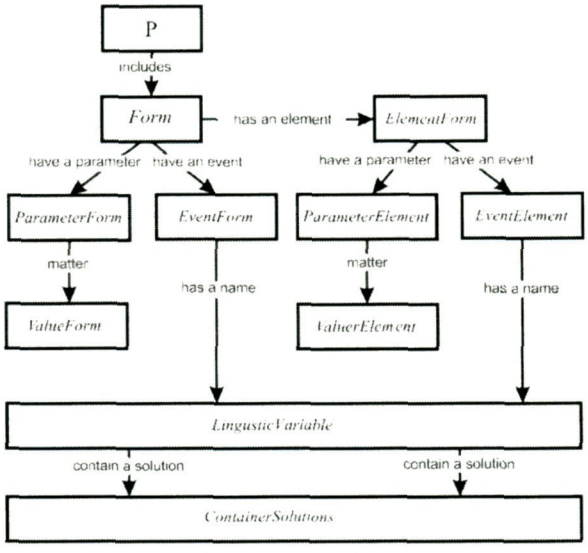

Fig. 1 Semantic Model

3. Bibliography

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OBJECT SEMANTIC MODEL FOR LIFE CYCLE MODEL "JUMP"

Summary

On the base of proposed model a methodology for CAx systems design automation will be developed.

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PROPOSAL FOR THE IDENTIFICATION OF DYNAMIC PARAMETERS OF CRANKSHAFT SYSTEMS

1. Introduction

The paper presents proposition of methodology for modeling crankshaft dynamics with including of flexural and torsional vibrations. The proposed approach is qualitatively better than that which could be found in the literature. The main focus was on determining the crankshaft stiffness matrix using the theory of linear-elastic systems and the Maxwell-Mohr theorem.

2. Mathematical model of crankshaft

To construct the crankshaft model, author developed the crankshaft model based on the self-developed finite element (Fig. 2) and the algorithm transforming the stiffness matrix of the one-sided fixed system into the free-end system (equations 1 - 8). The model was constructed using six generalized coordinates. Fig. 1 shows the load diagram and assumed coordinates..

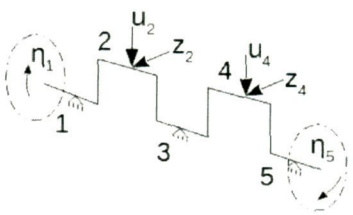

Fig. 1 Scheme of generalized coordinates and load distribution

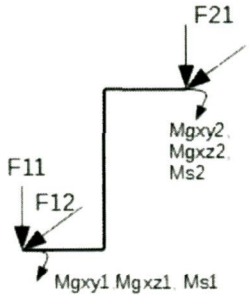

Fig. 2 Finite element load diagram

$$F_{obciążenia} = K \cdot \widetilde{U} \tag{1}$$

$$\widetilde{U} = U_p - U_l \tag{2}$$

$$U_p = G \cdot U_{p1} \tag{3}$$

$$F_{obciążenia} = K \cdot U_l - K \cdot U_p = K \cdot U_l - K \cdot G \cdot U_{p1} \tag{4}$$

$$F_{obciążenia} = [K \quad K \cdot G] \cdot \begin{bmatrix} U_p \\ U_{l1} \end{bmatrix} \tag{5}$$

$$F_{obciążenia} = K_\Sigma \cdot U \tag{6}$$

$$F_{reakcji} = H \cdot F_{obciążenia} = H \cdot K_\Sigma \cdot U \tag{7}$$

$$F_{całkowite} = \begin{bmatrix} F_{obciążenia} \\ F_{reakcji} \end{bmatrix} \begin{bmatrix} K_\Sigma \\ H \cdot K_\Sigma \end{bmatrix} \cdot U \tag{8}$$

Where:

- $F_{obciążenia}$ – external load forces,
- K – stiffness matrix of the walled element,
- $\widetilde{U}$ – fixed system deflection vector,
- G – matrix of node displacement geometry,
- K_Σ – stiffness matrix in a global coordinate system
- U – vector of generalized displacements
- H – reaction force matrix depends on reaction force vector,
- $F_{całkowite}$ – vector of nodal forces.

Formula (9) is a crankshaft stiffness matrix constructed by aggregation of the stiffness matrix of a finite element and removal of unnecessary nods.

$$K = \frac{EI}{l} \cdot \begin{bmatrix} \frac{3,84}{l^2} & -\frac{1,24}{l} & 0 & 0 & 0 \\ -\frac{1,24}{l} & \frac{3,84}{l^2} & 0 & 0 & 0 \\ 0 & 0 & \frac{2,2}{l^2} & -\frac{0,22}{l^2} & \frac{0,078}{l} \\ 0 & 0 & -\frac{0,22}{l^2} & \frac{0,044}{l^2} & -\frac{0,028}{l^2} \\ 0 & 0 & \frac{0,078}{l} & -\frac{0,028}{l^2} & 0,13 \end{bmatrix} \quad (9)$$

3. Simulations

Based on the determinant stiffness matrix, Lagrange type II equations were used for knowing equations of motion. Numerical simulations were then performed. The obtained results show an influence of the flexural and torsional vibrations on the structure of the vibration spectrum (Fig. 3).

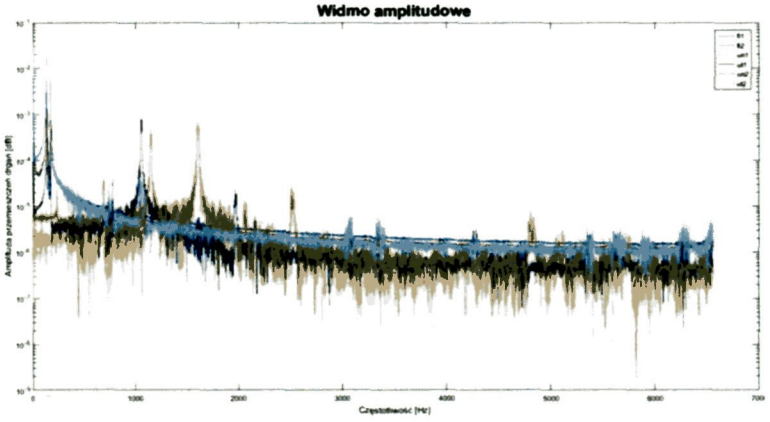

Fig. 3 Results of simulations

3. Test stand

A modal experiment was performed on the FIAT TwinAir engine and its vibration spectrum was analyzed (Fig. 5). The results show similar behavior of the spectral structure as in the simulations. Fig. 4 shows a test stand diagram.

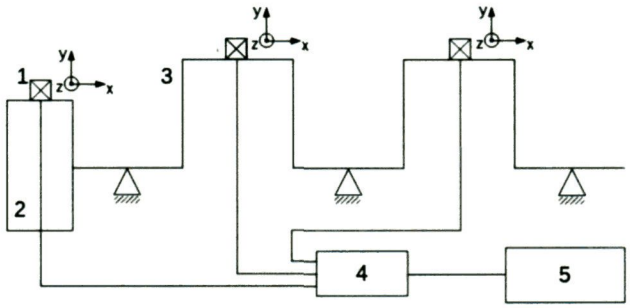

Fig. 4. Diagram of test stand. 1. Sensor, 2. Flywheel, 3. Crankshaft, 4. Measure card, 5, PC.

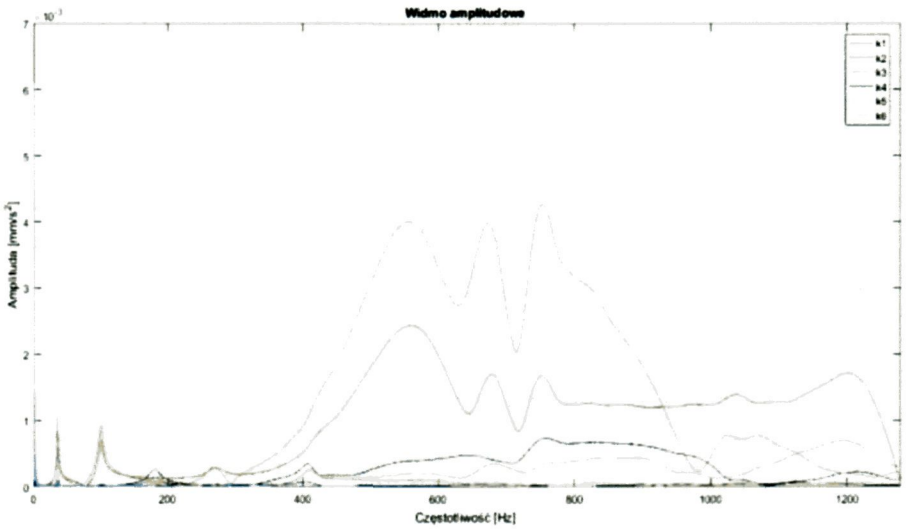

Fig. 5. Results of experiments.

4. Conclusions

Studies have shown that it is possible to determine an effective method for modeling crankshaft stiffness. Dynamic simulations show the influence of torsionally twisted vibration on the crankshaft frequency structure. In the obtained results, the bands of torsional and flexural vibrations were found. Normal vibration frequencies are greater than torsional vibrations. This confirms the correctness of the proposed approach to modeling the stiffness of the crank system. In addition, the results obtained qualitatively agree with the models presented in the literature on the simplifications used there. This means that the proposed method may be a generalization of the previous approach to the problem of modeling of crankshaft and crankshaft oscillation.

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PROPOSAL FOR THE IDENTIFICATION OF DYNAMIC PARAMETERS OF CRANKSHAFT SYSTEMS

Summary

A methodology of modeling crankshaft stiffness matrix has been proposed. The proposed methodology may be a generalization of literature methods. Simulations show the significant influence of coupling of torsional and bending vibrations on the structure of the crankshaft vibration spectrum.

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ACOUSTIC MODEL OF VACUUM PACKED PARTICLES

Abstract: In this paper a new kind of granular acoustic media is presented. The Vacuum Packed Particles (VPP) are investigated for controllable sound absorption, with internal underpressure working as a trigger for jamming mechanism, that changes the structure and also the properties of the conglomerate. With good test results a layer of VPP could be used in the future as a part of a novel layered sound absorber with changeable properties. Also included in the paper is an attempt to model this new type of absorbing material. The model is based on an existing one, created especially for granular media.

Keywords: Vacuum Packed Particles, modeling, underpressure, experiments

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ACOUSTIC APROACH TO MEASUREMENT OF MICROSCOPIC LINEAR MOVEMENTS

1. Introduction

The research is focused on developing approach of linear size and movement measurements using acoustic waves. Research was done using acoustic wave effects such as sound wave interference and acoustic standing wave.

2. Development of the acoustic approach to measurement of linear movements

For controlling object's movement using sound wave interference effect the device consisting of speaker, microphone and sound-path ("probe" further on) was used. Probe structure is show on Fig. 1.

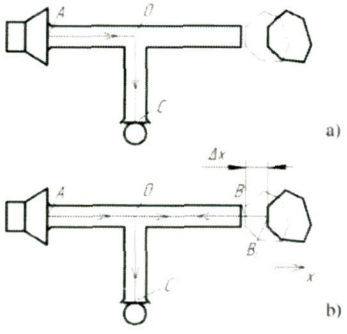

Fig. 1. Wave path length difference during object's movement:
a) – carrier wave path; b) – measuring wave path while the object is in motion

Experimental set-up drawing is show on Fig. 2.

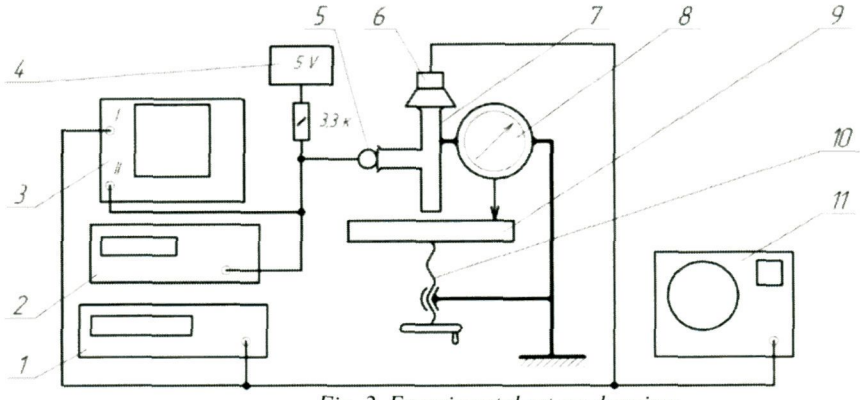

Fig. 2. Experimental set-up drawing:
1 – Frequency counter; 2 – electronic voltmeter; 3 – electronic oscilloscope;
4 – microphone power adapter; 5 – microphone; 6 – speaker; 7 – probe; 8 – clock type indicator; 9 – measuring table; 10 – micrometric screw; 11 – sound generator.

Graphical plot of the $U_i = f(x_i)$ dependency has been created based on the experimental results (Fig. 3) for the frequency 3940Hz (probe's fourth resonance harmonic)

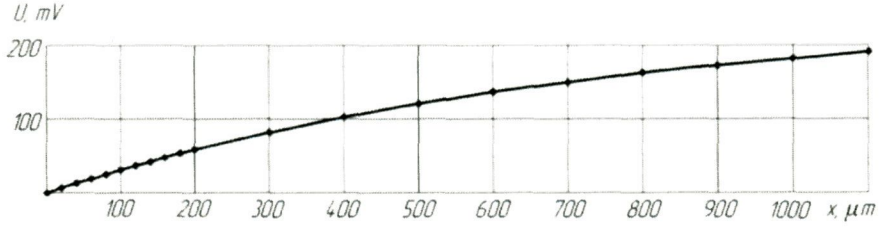

Fig. 3. Static measurement system characteristic for the frequency of 3940Hz

Plot on Fig. 3 shows that characteristic remains close to linear in scope 0...200μm. Average sensitivity S in this scope equals to 0,295 mV/μm. Relative deviation caused by non-linearity in the middle of the scope equals to 1,69%.

ACOUSTIC APROACH TO MEASUREMENT OF MICROSCOPIC LINEAR MOVEMENTS

Summary

Presented approach was proved to be useful for registering of movements and linear length deviations. Experimental set-up and research methodology were created. Among benefits of the proposed acoustic measurement approach can be mentioned: contactless measurement, fast response time, remote measurement, signals processing simplicity, possibility of automated usage, low production cost.

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EVALUATION OF THE TOOTH CONTACT IN BEVEL GEAR AS A PROBLEM OF THE CONTACT ISSUE OF SPIRAL TEETH

The paper presents a proposal to evaluate the tooth contact as a contact issue with the use of FEM analysis in a system supporting engineering calculations (CAE) ANSYS. In this case, the tooth contact is evaluated as the contact surface of the teeth in the spiral bevel gear pair under load with a low friction coefficient. An attempt was made to check the traces of the load under the real load, the so-called. Working co-operation map, which is mapped in the form of surface pressure maps on the teeth surface sides (face/flank). The analysis was carried out on the assumption of a simplification consisting in the omission of the support of the wheels (shafts, bearings). The tooth contact is thus formed by the cooperation of bevel gear pairs, without considering the deflection of the shaft. On the other hand, the aspect of load dynamics is taken into consideration by assuming the take-over time of the full load by the gears. The solid model of spiral bevel gears pair (pinion – crown wheel) has been developed in SolidWorks. Then, with the integration of computer techniques, using one of Parasolid *.x_t's standard geometry data exchange formats, these models have been imported into ANSYS.

According to the ANSYS: Mechanical Contact Best Practices Workbench guide for most cases, auto-asymmetric contact was used. In this case, the program makes a decision (*Program Controlled*). In the conducted contact issue analysis *Contact Bodies("MASTER")* was applied on the sides of the crown wheel teeth and *Target Bodies ("SLAVE")* – on the sides of the pinion teeth. Out of several different contact formulas for enforcing compliance at the surface contact, an advanced and accurate method has been

applied, currently default in ANSYS Workbench Mechanical – Augmented Lagrange Method, for solving compound contact problems. Although it creates a slight, insignificant level of penetration, it is generally so small that its effect is negligible. For contact detection, the contact parameter corresponds to the spherical contact detection limit as *Pinball Region* that is involved with the distance from contact element to target element in a given contact region, categorizing *Touching* or *Near field* or *Far field*. If the elements on the target surface were in the *Pinball Region*, the program considered that they were close to the contact (touch) and closely monitored contact point detection (touch points). Outside the *Pinball Region*, contact detection of the contact surface sides of *Contact* and *Target* (crown wheel and pinion) teeth was inactive. The pinball region size for each contact point detection was controlled by the program based on the type and size of the finite element. In the numerical study of the spiral bevel gear model was used the frictional contact with the friction coefficient 5e-2.The unequal division of the solid gears model continuum into finite elements of the *Tet10, quadratic tetrahedron*, forcing a tenfold smaller size on the teeth surface sides (face/flank), i.e. 0.5 mm, was used. The compound geometry of the spiral bevel gears made it necessary to build a model composed of a large number of finite elements (over 385000) to ensure the adequacy of the model and the ability to obtain reliable analysis results.

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DEVICE FOR ACCURATE DOSING OF LIQUIDS

1. Introduction

Over the last few decades, the devices for dispensing liquids have passed the stage of their formation and have formed wide possibilities of applied application in various fields. One of the applications for use of devices is the liquid microsystems containing a microchannel network for the transfer and study of biological fluids in the micro or nanolithic dose. According to the data obtained after studying the created device, it was found that for each symbol in size 10, use 4•10-10l. After conducting several more studies and calculations, it was found that with an increase in the size of the font by 1, then the volume of transmitted fluid will increase by 1.21 times.

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DEVICE FOR ACCURATE DOSING OF LIQUIDS

Summary

During the development of the project, there are realized the tasks:
- modeling and analysis of the types of channels for fluid flow or a mixture of liquids was carried out;
- a device for accurately dispensing liquids was built;
- measurements and calculations for liquid dosing;
- calculation of possible variants of symbols satisfying the received data from the calculations.

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DEVELOPING A SYSTEM OF AUTOMATED DATA DISTRIBUTION FOR CLOUD STORAGE

1. Introduction

From the integration of computers and mobile devices into everyday life, the amount of data in electronic form increases with each passing year. The realities have shown that the storage of important personal data on devices is not reliable and there is no remote access to the necessary data. Cloud storages such as Google Drive, Dropbox, One Drive, and others can solve this problem.

2. Development of algorithm for data distribution in cloud environments

The system is based on working with cloud environments, accessed by the interface of the software Web service (API) or applications that use the API. They provide a convenient way to manage data in a cloud environment. The system provides the user with the ability to perform data operations such as downloading in a cloud environment, deleting and unloading a document(s) from a cloud environment on data files. In the system settings, the user can monitor the used and available memory for each of the cloud environments provided.

When downloading a file, the system analyzes cloud environments to optimize data sharing. The object of analysis in the system is the size of unused memory in each environment.

The algorithm for distributing files when downloaded to cloud environments is based on solving the problem of packaging in containers. The main objective of this task is to pack certain objects of defined weight in containers of a specified capacity in such a way that the number of used containers is the smallest.

This system is developed on the .NET platform. The popularity of this platform provides developers with access to new tools for creating software products. WPF technology is used to create graphical user interfaces.

To access the cloud environment, tools are available that allow developers to manage data, such as Google Drive APIs and the Dropbox API.

To get started with the cloud environment API, you need to get the file with the access settings.

After verifying the cloud storage data permission, the user can manage his account with third-party software. Similarly, you can obtain the configuration file to the Dropbox cloud storage and other widely used storage.

An API is needed not only to perform operations for downloading, deleting, and receiving user files from a cloud environment, but also for the operation of the data distribution algorithm. Using the API, the system receives data about the amount of used and available memory usage in the cloud environments on which the work of the BFA algorithm is based.

The general system structure is presented in the Fig.1.

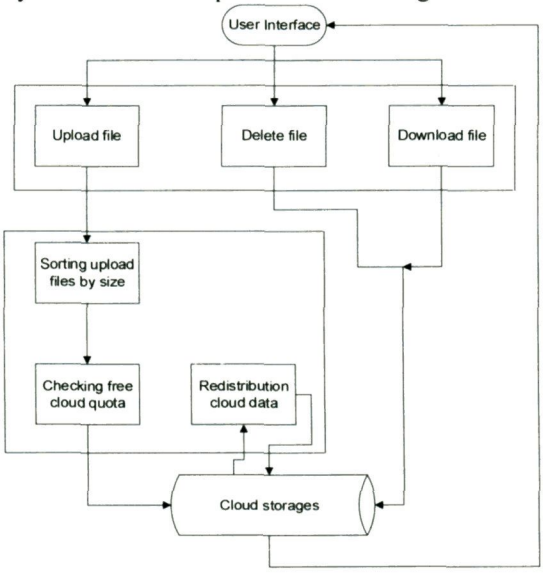

Fig.1 System structure

DEVELOPING A SYSTEM OF AUTOMATED DATA DISTRIBUTION FOR CLOUD STORAGE

Summary

The system for automated data distribution on cloud environments is developed. It works with major cloud services, such as Google Drive and Dropbox. The system's novelty is using data distribution algorithm, Best Fit Algorithm, which optimally distributes all downloaded data in secure cloud environments. If necessary, the system will redistribute existing data for more optimal file allocation.

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ODOMETRY CALCULATION OF WHEELED VEHICLE MODEL IN GAZEBO AND ROS ENVIRONMENT

1. Introduction

Gazebo is open-source robotics simulation environment [1]. It provides simulation of robotics models in indoor and outdoor environments. Gazebo support simulation of many kind of sensors, such as Lidar, ultrasonic sonar, GPS, video camera and other. This allows to create accurate and fully functional robotics models able to interacts and sense surrounding environment. Also Gazebo provide API for communication with virtual world and to extend the system with new required components.

2. Gazebo Vehicle Model

Gazebo Vehicle model used in simulation is created based on *Polaris Ranger XP900* car model. The model is open-source and was created by Open Source Robotics Foundation (OSRF) special for DARPA Robotics Challenge (DRC) initial competition, also know as Virtual Robotics Challenge (VRC). The vehicle model has model plugin *DRCVehicleROSPlugin* connected. The plugin programmatically simulates vehicle internal mechanisms, such as steering wheel, gas and brake pedals, hand brake, power train and Ackermann steering. This means that vehicle rotates front wheels when steering wheel is rotated, brakes or accelerate according to pedals position etc. Also the plugin implements ROS topics interface which allows car control by sending commands to appropriate topics.

Odometry calculation requires sensing of front wheels rotations. Gazebo doesn't provide odometer sensor in the box. But it is possible to create model plugin simulating odometer. The plugin is connecter to the vehicle model and sense rotary of the wheels

joints. Sdf-file of the model with connected odometers presented in Fig. 1. Odometer plugins broadcasts rotary data in a message to ROS environment via special ROS topic [1]. The message contains rotary angle displacement and time passed from last measurement. Those messages are listened by special ROS node which calculated vehicle odometry based on the data.

Fig.2 Gazebo Vehicle model with joint gizmos displayed.

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ODOMETRY CALCULATION OF WHEELED VEHICLE MODEL IN GAZEBO AND ROS ENVIRONMENT

Summary

Estimated vehicle movement can be calculated from a continuous wheel rotary data received from odometers. Disadvantage of the method is low accuracy and error accumulation. Main advantage is easy implementation and robustness in city environment. The odometry usually is used in fusion with other sensors and navigation methods (GPS, IMU, SLAM) to achieve vehicle position in world space.