Modelling of Thermal Behaviour of Iron Oxide Layers on Boiler Tubes

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Keywords: Boilers tubes, heat transfer, oxides layer.

Abstract: Slender boiler tubes are subject to localised swelling when they are exposed to excessive heat. The latter is due to the formation of an oxide layer which acts as an insulation barrier. This excessive heat can lead to microstructural changes in the material that would reduce the mechanical strength and would eventually lead to critical and catastrophic failure. Detecting such creep damage remains a formidable challenge for boiler operators. It involves a costly process of shutting down the plant, performing electromagnetic and ultrasonic non-destructive inspection, repairing or replacing damaged tubes and finally restarting the plant to resume its service.

This research explores through a model developed using a finite element computer simulation platform the thermal behaviour of slender tubes under constant temperature exceeding 723 °K. Our simulation results demonstrate that hematite layers up to 15μm thickness inside the tubes do not act as insulation. They clearly show the process of long term overheating on the outside of boiler tubes which in turn leads to initiation of flaws.

Optimal Energy Harvesting from Vortex-Induced Vibrations of Straight Cables

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Keywords: Vortex-induced vibrations, renewable energy, wake-oscillator model.

Abstract. We use a simple, validated, physics-based model and numerical tools to assess the performance of a system harvesting energy from the flow induced vibrations of a cable immersed in a geophysical flow. The fluid force is modeled with a wake oscillator which is coupled with the equation of motion for the cable. We consider a distributed harvester modeled as a structural displacement-based damping and we optimize its distribution for different deformation modes of the cable. We find that the optimal strategy is to concentrate the structural damping on a reduced portion of the cable near one of its extremity. Thus, the results suggest that we consider the limiting case of a cable with one end attached to a localized harvester. This simple system turns out to perform as well as the one considered in the first place.

Chaotic and noisy-chaotic dynamics of slender structures

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In this work we study mathematical models of continuous structural members (beams and plates) under harmonic load and under white noise. The applied numerical procedures are verified and validated. Spatial-temporal chaotic vibrations of a plate and two/three beams coupled only by boundary conditions are analyzed. Novel transition scenarios from regular to chaotic dynamics of the mentioned deterministic systems are reported. We illustrate why the wavelet analysis is needed while studying chaotic vibrations. The modifications of classical three scenarios of transition from regular vibrations to deterministic spatial-temporal chaos are proposed and validated.. We present a few numerical examples showing that the added noisy components do not only yield the quantitative changes in the system dynamics, but also cause the qualitative, and sometimes surprising changes in the system vibration regimes. We illustrate how the white noise lowers the threshold for transition into spatial-temporal chaotic dynamics and how it significantly reduces occurrence of periodic vibrations. Scenario of transition into chaos of the studied mechanical structures essentially depends on the control parameters, and it can be different in different zones of the constructed charts of vibration kinds (control parameter planes). Furthermore, we found two interesting non-linear phenomena, when increase of the noise intensity yields surprisingly the vibrational characteristics with a lack of noisy effect (chaos is destroyed by noise and windows of periodicity appear) and when the symmetric dynamical regime of the investigated system loses its symmetry due to action of a small white noise symmetrically distributed.

A TOUR OF NONLINEAR DYNAMIC ANALYSIS OF ELASTIC STRUCTURES EXCITED BY NON-IDEAL SOURCES (NIS)

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Keywords: nonlinearities, structural elastic systems, vibrating systems with limited power supply.

Abstract. This paper overviews recent developments on some problems related to elastic structures, such as portal frames, taking into account the existence of full interaction of the vibrating systems with energy sources of limited power supply (small motors and electro-mechanical shakers).

Modal Analysis of Sailplane and Transport Aircraft Wings Using the Dynamic Stiffness Method

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Abstract

Sailplane and transport aircraft wings are slender and flexible because of their high aspect ratios resulting from large spans and relatively short chords. As a consequence, they are prone to undesirable dynamic and aeroelastic phenomena such as flutter and gust response which must be checked against to ensure structural integrity and safety of the aircraft. In this respect, modal analysis of an aircraft wing plays an important role in the design process. An analysis of this type is a mandatory airworthiness requirement, stringently demanded by the civil aviation authorities. The purpose of this paper is to carry out such an analysis and investigate the modal behaviour of sailplane and transport aircraft wings with cantilever boundary conditions. This is achieved by taking a rigorous recourse to the dynamic stiffness method through the application of the Wittrick-Williams algorithm as the solution technique. In essence, the aircraft wing is idealised as an assemblage of the frequency dependent dynamic stiffness elements of bending-torsion coupled beams, comprising both the mass and stiffness properties of the wing. Once the overall dynamic stiffness matrix of the cantilever wing is formed, the eigenvalue problem is formulated. Next the Wittrick-Williams algorithm which monitors the Sturm sequence property of the dynamic stiffness matrix is invoked to extract the natural frequencies of the wing. Following the eigen-solution procedure, the mode shapes corresponding to each natural frequency are recovered in the usual way by choosing a displacement component at a particular node and then expressing the relative displacement components of the rest of the nodes in terms of the chosen one. Illustrative examples are given for wings of two sailplanes and two transport aircraft of varying degrees of complexity. Natural frequencies and mode shapes are computed and the results are compared and contrasted. A parametric study is undertaken by changing significant wing parameters including the bending and torsional stiffnesses of the wing and their subsequent effects on the natural frequencies and mode shapes are illustrated. The results are critically examined and discussed and some conclusions are drawn.

Prediction of Hydrodynamic bearing performance based on effective parameters by Neural Network

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Keywords: Hydrodynamic bearing, Neural Network,MLP

Abstract. Condition monitoring of rotary device is one of the major concerns which all industries have followed the new method for preventing unpredicted failure. In this way predictive maintenance (PM) is the most significant part of our industries. In this work, the main objective is to analyze the variation of three parameters including, Shear stress, Power losses and RMS (as an acoustic emission feature) on hydrodynamic journal bearing under different lubricants for various loading conditions and various rotational speeds. The results obtained experimentally from variation of parameters at different levels lead to find the relationship between output parameters and input factors. Artificial neural network (ANN) by using multilayer perceptron algorithm is applied to process the set of large number data from the test, with 80% used for training and 20% used for testing the predicted model. In addition to this, 20% of real data have been applied for test of the mentioned network. The accuracy of predicted model is about 0.001. The results show that the presented model from neural networks, constituting methodical basis for the control and diagnostics the bearing without prior knowledge of the relative rotational speeds or load conditions can be predicted with reasonable accuracy which hitherto has not been explored. Also, this method can utilize for the Interpolation of parameters which cannot be tested in real condition for the assessment of behavior of output parameters.

A New Singularity-free Formulation of a Three-dimensional Euler-Bernoulli Beam with Application to Elevator Traveling Cables

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Abstract: A new singularity-free formulation of a three-dimensional Euler-Bernoulli beam with large deformations and large rotations is developed. The position of the centroid line of the beam is integrated from its slope, which is expressed by Euler parameters to resolve the singularity problem caused by Euler angles. Since position vectors of nodes of beam elements are no longer used as generalized coordinates, the number of generalized coordinates for each node is minimized. A new C_1-continuity interpolation function is developed for Euler parameters, which can greatly reduce the number of elements. Since Euler parameters have normalization constraints, governing equations of the beam are differential-algebraic equations, which can be solved by the generalized-α method. After simulating several examples to verify the efficient and accuracy of the current formulation, it is used to model an elevator traveling cable. Equilibria of a traveling cable with different cable parameters and car positions are first calculated. The results are compared with those calculated by its planar model. Natural frequencies and mode shapes of the traveling cable are calculated from the current formulation, which are compared with those from ABAQUS. Then free responses of the traveling cable due to motion of the car are calculated from the current formulation and absolute nodal coordinate formulation. Finally, forced responses of the traveling cable due to different types of building sways are calculated and their effects are analyzed.

Self-Weight Loading of Horizontal Multi-Section Hydraulic Cylinders

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Long hydraulic cylinders with up to five sections are used in earth moving and mining vehicles. When fully extended, these are subject to large bending loads due to self-weight, which causes large loads on the seals. This is exacerbated by the added bending caused by the large end loads.

Analysis is based on the well-known MacAulay's method by double integration, made complicated by the different cross section, and hence 2nd moment of area, of the various sections of the cylinder. The effect of the end loading is to increase the bending, and hence the bending moment and radial loads on the seals. The combined bending moment, and hence seal load, is determined by an iterative method.

The conventional mounting arrangement for this type of cylinder is by pin joints at the ends. It is shown that a reduced seal loading can be achieved by the use of encastré or "built-in" mounting, which reduces the maximum bending moment near the mid-span.

Finally, the effect of misalignment of the end supports for the encastré mounts is analysed. It is shown that the improvement obtained is lost if alignment is not well maintained.

THE EFFECT OF TIME DELAYS ON CONTROL STABILITY OF AN ACTIVE TUNE MASS DAMPER

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Keywords: ATMD, system modelling and validation, time delays, stability

Abstract. Active tuned mass damper (ATMD) systems are used to mitigate the effects of vibrations in tall slender structures such as high rise buildings and towers as well as in machinery. This work investigates the effect of time delays on the stability of the implementation of a feedforward/zero-placement with position and velocity feedback control strategy for an ATMD. The main aim of this work is broadening the vibration attenuation envelope of a primary mass in a higher frequency region identified as from 50±0.5Hz with a passive tuned mass damper (TMD) to a wider range of 50±5Hz with an ATMD. A computer simulation study was carried out to investigate the position of the system poles for different time delays at different excitation frequencies. The results revealed that the proposed control system is subject to instability after a certain time delay margin depending upon the frequency of excitation. The findings were illustrated following the implementation of the active vibration control algorithm with time delays. A further simulation study investigated a potential solution of the time-delay inflicted instability in the control system. The proposed solution was successfully validated using an experimental setup.

Simple models for rope substructure mechanics: Application to electro-mechanical lifts

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Keywords: Dynamics, Mechanical Modelling, Lift Simulator, Vibration Analysis.

Abstract. Mechanical systems modelled as rigid mass elements connected by tensioned slender structural members such as ropes and cables represent quite common substructures used in lift engineering and hoisting applications. Special interest is devoted by engineers and researchers to the vibratory response of such systems for optimum performance and durability. This paper presents simplified models that can be employed to determine of the natural frequencies of systems having substructures of two rigid masses constrained by tensioned rope/ cable elements. The exact solution for free undamped longitudinal displacement response is discussed in the context of simple two-degree-of-freedom models. The results are compared and the influence of characteristics parameters such as the ratio of the average mass of the two rigid masses with respect to the rope mass and the deviation ratio of the two rigid masses with respect to the average mass is analyzed. This analysis gives criteria for the application of such simplified models in more complex elevator and hoisting system configurations.

Software design to calculate and simulate the mechanical response of electromechanical lifts

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Keywords: Dynamics, Mechanical Modelling, Lift Simulator, Vibration Analysis.

Abstract. Lift engineers and lift companies which are involved in the design process of new products or in the research and development of improved components demand a predictive tool of the lift slender system response before testing expensive prototypes. A method for solving the movement of any specified lift system by means of a computer program is presented. The mechanical response of the lift operating in a user defined installation and configuration, for a given excitation and other configuration parameters of real electric motors and its control system, is provided. A mechanical model with 6 degrees of freedom is used. The governing equations are integrated step by step through the Meden-Kutta algorithm in the MATLAB platform.

Input data consists on the setpoints speed for a standard trip and the control parameters of a number of controllers and lift drive machines. The computer program computes and plots very accurately the vertical displacement, velocity and instantaneous acceleration of the car, counterweight, frame, passengers/loads and lift drive in a standard trip between any two floors of the desired installation. The resulting torque and deviation of the velocity plot with respect to the setpoints speed are shown. The software design is implemented in a demo release of the computer program called VIBRELEV-1G. Further on, the program offers the possibility to select the configuration of the lift system and the performance parameters of each component. In addition to the overall system response, detailed information of transients, vibrations of the lift components and frequency spectrum are plotted.

Dynamic response of mechanical systems to impulse process stochastic excitations: Markov approach.

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Keywords: random vibrations, random impulses, Poisson process, renewal process, integro-differential Chapman-Kolmogorov equation, moment equations, response probability density.

Abstract. Methods for determination of the response of mechanical dy- namic systems to Poisson and non-Poisson impulse process stochastic excitations are presented. Stochastic differential and integro-differential equations of motion are introduced. For systems driven by Poisson impulse process the tools of the the- ory of non-diffusive Markov processes are used. These are: the generalized Itô's differential rule which allows to derive the differential equations for response mo- ments and the forward integro-differential Chapman-Kolmogorov equation from which the equation governing the probability density of the response is obtained. For systems driven by a class of non-Poisson (Erlang renewal) impulse processes an exact conversion of the original non-Markov problem into a Markov one is based on the appended Markov chain corresponding to the introduced auxiliary pure jump stochastic process. The derivation of the set of integro-differential equations for response probability density and also a moment equations technique are based on the forward integro-differential Chapman-Kolmogorov equation.

On the Mechanics of Elastic Continua with Bending Stiffness Wrapping on a Pulley System

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Keywords: Elastic Continua, Bending Stiffness, Boundary Value Problem, Undetermined Boundary Conditions, Angle of Wrap, Tension.

Abstract. In many engineering applications elastic continua such as ropes and belts often are subject to bending when they pass over pulleys / sheaves. In this paper the quasi-stationary mechanics of a cable-pulley system is studied. The cable is modelled as a moving Euler-Bernoulli beam. The distribution of tension is non-uniform along its span and due to the bending stiffness the contact points at the pulley-beam boundaries are not unknown. The system is described by a set of nonlinear ordinary differential equations with undetermined boundary conditions. The resulting nonlinear Boundary Value Problem (BVP) with unknown boundaries is solved by converting the problem into the 'standard' form defined over a fixed interval. Numerical results obtained for a range of typical configurations with relevant boundary conditions applied demonstrate that due to the effects of bending stiffness the angels of wrap are reduced and the span tensions are increased.

Amplitudes of non-linear vibrations of stay cables and resulting local bending fatigue

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Keywords: Non-linear dynamics, Bending fatigue; Cables; Local stresses; End fixity.

Abstract. Large amplitude cable vibrations are remarkably common on cable-stayed bridges, due to various aerodynamic loading mechanisms and/or motion of the cable ends. Geometric non-linearity can be important in the dynamic behaviour and significant local bending stresses can arise at the anchorages, where rotation is restrained. This then leads to a concern about the fatigue of these cables from the cyclic stress variations. Information has only recently become available in the public domain on the fatigue of the seven-wire strand commonly used as stay cables, due to bending, rather than axial, stress variations. This paper presents a methodology for the estimation of the fatigue life of cables due to dynamic loading. Firstly an analytical solution is presented for the steady state amplitude of non-linear vibrations of low-sag cables. In certain conditions planar cable vibrations become unstable, leading to whirling motions, or parametric excitation can cause large cable responses at half the excitation frequency. The resulting bending stress variations at or near the anchorages are then addressed and, following appropriate cycle counting for multi-modal responses, rates of fatigue damage can be estimated. It is shown that for typical cables on long-span cable-stayed bridges, vibrations can cause quite high rates of fatigue damage so it is important that the vibrations do not jump onto large amplitude solutions.

Active vibration control of Parametrically Excited Systems

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In this paper, analysis and control of parametrically excited systems is presbented. Parametric resonance is observed in a wide range of applications and can lead to high levels of unwanted motion. One particular example in which parametric resonance may lead to instability is in cable-stayed bridges. The vibration of the deck can axially excite the cable and if the frequency of the excitation is twice the natural frequency of the cable, parametric resonance can occur, leading to large amplitudes of cable vibration.

Parametrically excited systems exhibit complex dynamic behaviour such as inherent instability, limit cycle oscillation and combined resonances. In this paper, two examples of parametrically excited systems are presented. The first example is an electromagnetic beam with two magnets and coils. The AC current through the coils can generate a periodic time-varying stiffness in the beam. The second example is a beam subjected to an axial harmonic load, with time-varying tension. The parametric stability of the two beams is assessed both analytically and experimentally. Active control can be used to stabilise or to increase the stability regions of parametrically excited systems, using both velocity feedback and pole placement. Some aspects of both techniques are discussed such as their effects on transition curves and stability diagram. Finally, active control experiments are carried out to show the effectiveness of velocity feedback and pole placement for stabilising the beam using a Macro Fiber Composite patch.

Assessment of active vibration control strategies using Mechanical-Electrical Analogies

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Keywords: active DVA, vibration isolation, lumped electrical-mechanical circuit, voice coil motors.

Abstract. Mechanical-electrical analogous circuit models are widely used in electromechanical system design as they represent the function of a coupled electrical and mechanical system using an equivalent electrical system. This research uses electrical circuits to establish a discussion of simple active vibration control principles using two scenarios: an active vibration isolation system and an active dynamic vibration absorber (DVA) using a voice coil motor (VCM) actuator. Feedforward/zero-placement active control laws such as position-velocity and acceleration-velocity feedback are intuitively explained using circuit analysis techniques.
Active vibration control approaches are typically constraint by electrical power requirements. The electrical analogous is a fast approach for specifying power requirements on the experimental test platform which is based on a vibration shaker that provides the based excitation required for the single Degree-of-Freedom (1DoF) vibration model under study.

Mechanical Discrete Simulator of the Electro-mechanical Lift with n:1 roping

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Keywords: Dynamics, Mechanical Modelling, Lift Simulator, Vibration Analysis.

Abstract. The design process of new products in lift engineering is a difficult task due to, mainly, the complexity and slenderness of the lift system, demanding a predictive tool for the lift mechanics. A mechanical ad-hoc discrete simulator, as an alternative to 'general purpose' mechanical simulators is proposed. Firstly, the synthesis and experimentation process that has led to establish a suitable model capable of simulating accurately the response of the electromechanical lift is related. Then, the equations of motion are derived. The model comprises a discrete system of 5 vertically displaceable masses (car, counterweight, car frame, passengers/loads and lift drive), an inertial mass of the assembly tension pulley-rotor shaft which can rotate around the machine axis and 6 mechanical connectors with 1:1 suspension layout. The model is extended to any n:1 roping lift by setting 6 equivalent mechanical components (suspension systems for car and counterweight, lift drive silent blocks, tension pulley-lift drive stator and passengers/load equivalent spring-damper) by inductive inference from 1:1 and generalized 2:1 roping system. The application to simulate real elevator systems is proposed by numeric time integration of the governing equations using the Kutta-Meden algorithm and implemented in a computer program for ad-hoc elevator simulation called VIBRELEV-1G also presented to this Congress.

On transversal vibrations of axially moving strings and their mathematical analysis

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Keywords: axially moving strings, multiple times scales perturbation method, applicability of Galerkin's truncation method, method of characteristic coordinates.

Abstract

In this paper the transversal vibrations of an axially moving string with constant or time-varying length, time-varying velocity, and/or time-varying tension are studied. By using a multiple timescales perturbation method, asymptotic approximations of the solutions of the formulated initial-boundary value problems are constructed. The applicability of Galerkin's truncation method and the applicability of the method of characteristic coordinates for these types of problems are discussed. The presence of internal resonances and autoresonances are described in detail.

For conveyor belt problems it will be shown how the two timescales perturbation method in combination with the method of characteristic coordinates can be used to construct asymptotic approximations of the solutions on long timescales. Also for these conveyor belt problems it turned out that Galerkin's truncation method was not applicable to obtain asymptotic results on long timescales.

Influences on lifetime of wire ropes in traction lifts

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Keywords: wire ropes, lifetime, discard, new limits, calculation methods, research

Abstract.

Traction lifts are complex systems with rotatory and translatory moved masses, springs and dampers and several system inputs from the lifts and the users. The wire ropes are essential mechanical elements.The mechanical properties of the ropes in use depend on the rope construction, the load situation, nonlinearities and the lift dimensions. The mechanical properties are important for the proper use in lifts and the ride quality. But first of all the wire ropes (for all other suspension means as well) have to satisfy the safety relevant requirements sufficient lifetime, reliable determination of discard and sufficient and limited traction capacity. The lifetime of the wire ropes better the number of trips until rope discard depends on a lot of parameters of the rope and the rope application eg use of plastic deflection sheaves and reverse bending layouts. New challenges for rope lifetime are resulting from the more or less open D/d-ratio limits possible by certificates concerning the examination of conformity by notified bodies. This paper will highlight the basics of wire rope technology, the endurance and lifetime of wire ropes running over sheaves, and the different influences from the ropes and more and more important from the lift application parameters. Very often underestimated are the influences of transport, storage, installation and maintenance. With this background we will lead over to the calculation methods of wire rope lifetime considering the actual findings of wire rope endurance research.

Dynamic Behavior of Elevator Compensating Sheave during Buffer Strike

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Keywords: elevator, rope tension, compensating rope, buffer strike, constraint force

Abstract This paper shows an elevator dynamic model that calculates the compensating sheave motion during a buffer strike. Our equivalent 2-degree-of-freedom vibration model of an elevator system, which consists of a car, a compensating sheave, and compensating ropes, can evaluate the dynamic tension of the compensating ropes caused by a buffer strike. The constraint force, which restricts the upward motion of the compensating sheave, is estimated from the dynamic rope tension. The constraint force is represented by the summation of two vibration modes and is the function of the limited distance of the compensating sheave's upward movement. Our formula, which evaluates the maximum constraint force, shows that a shorter limited distance of the compensating sheave increases the constraint force.

Complex Dynamics of Drill-String and BHA

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Abstract:

Despite a significant effort devoted to studying complexity of drill-string vibrations, robust and reliable models are yet to be developed. This is due to inherently nonlinear nature of the interactions occurring in a drill-string, where different types of vibrations are coupled to each other. Therefore, to gain a deeper insight into the complexity of the drill-string vibrations, a novel experimental rig has been developed at the Centre for Applied Dynamics Research, the University of Aberdeen.

We investigate complex dynamics of a drill-string and Bottom Hole Assembly (BHA) by theoretical and experimental means. Experiments are carried out on our newly developed rig, which is capable of reproducing all major types of drill-string vibrations. One of the most important features of this versatile setup is the fact that commercial drill-bits, employed in the drilling industry, and real rock-samples are used. The rig allows for different configurations, which enables experimental studies of various phenomena, such as stick-slip oscillations, whirling and drill-bit bounce.

We constructed and calibrated both FEM based and low dimensional dynamic models to predict complex responses of drill-strings and to avoid their undesired dynamic behaviours. The nonlinear dynamics modelling and stability analysis tools were employed to investigate global and local dynamic behaviours. These models can be used at the borehole planning stage and also to support dynamic analysis and control of deep-hole drilling processes.

In the lecture we will describe the new experimental drilling rig, identify its system parameters, build mathematical models and investigate dangerous dynamic phenomena such as stick-slip and whirling. A special attention will be paid to the onset of helical bucking.

Experimental Investigation of Vibration Isolation Characteristics of Periodic Curved Beams

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Keywords: periodic curved beam, vibration isolation characteristics, simulation, experiment.

Abstract. A periodic curved beam structure is designed based on its periodic structure band gap and waveform conversion mechanism. In order to analyze its vibration isolation characteristics, a periodic curved beam model is built in ANSYS and its frequency response is analyzed. Simulation results show that the periodic curved beam structure has good vibration isolation characteristics in a wide frequency band. Vibration transmission characteristics of a periodic curved beam isolation system that consists of periodic curved beams and two plates are experimentally validated. Experimental results show that the periodic curved beam isolation system has a lower and wider vibration isolation band and better vibration isolation characteristics than a traditional isolator.

Vibrations of beams and rods carrying a moving mass

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Keywords: Cantilever beam, moving mass, tip oscillations, Cosserat rod dynamics, large deformations, generalised α-method.

Abstract. We study the vibration of slender one-dimensional elastic structures (beams, cables, wires, rods) under the effect of a moving mass or load. We first consider the classical small- deflection (Euler-Bernoulli) beam case, where we look at tip vibrations of a cantilever as a model for a barreled launch system. Then we develop a theory for large deformations based on Cosserat rod theory and present some first results for a simple cable-mass system.

Large Port Load and Unload Machine Structure Damage Analysis Based on Impact Dynamics

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Keywords: Dynamic Impact, EA model, Dynamics Response, Simulation, Damage Analysis

Abstract. In this paper, taking the continuous ship unloader impacted by another one because of the wrong operation as an example, the FEA model base on drawing of this machine was built up. We had taken a deformation experiment that same displacement was done by jack on top of beam made as same to ship unloader. The most dangerous points and high stress areas were shown on model that was forced by maximal impact load according static impact and dynamic impact analysis. The results of this analysis could provide the targeted nondestructive testing of structure. The equipment management also could take the repair scheme according the results. The dynamics response factor could use in other similar impact accident and help the analysts to calculate equivalent static load quickly and accurately.