Development, Application and Challenge of High Temperature Acoustic Testing Technology

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Abstract Taking the research and application of high-temperature acoustic non-destructive testing technology in the fields of aerospace, steel metallurgy, and special equipment in China as the main line, this paper analyzes the huge demand for high-temperature acoustic testing technology in promoting the preparation and research, the development of advanced high-temperature material, green and low-carbon production and industrial upgrading in the iron and steel metallurgy industry, and the maintenance and safe operation of high-temperature pressure pipelines. This article introduces the progress made by domestic and foreign scholars in the technical methods and instrument development of high-temperature acoustic testing, analyzes the advantages, disadvantages, and application scenarios of technologies such as piezoelectric ultrasound, electromagnetic ultrasound, laser ultrasound, and laser electromagnetic ultrasound in high-temperature non-destructive testing, and summarizes the opportunities and challenges faced by high-temperature acoustic testing technology.

Keywords acoustic testing; high temperature non-destructive testing; piezoelectric ultrasound; electromagnetic ultrasound; laser ultrasound

System Updating and Response Prediction of a Cable-Stayed Bridge Based on Digital Twins

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Abstract Traditional modeling approaches are difficult to reflect the slight changes of bridge system parameters and responses. Due to this, digital twins are adopted as the high fidelity mapping models for a bridge system. Firstly, the definition of digital twins comprises three parts of a physical twin layer, a digital twin layer and an information interaction medium. The digital twin model inside the digital twin layer is the virtual mapping of the bridge physical entity, and the real-time information transmission between the two layers is achieved by the information interaction medium. Secondly, in view of practical applications, three modeling principles of structural informatization, information digitization and data modelization are proposed to realize the informatization and visualization of the bridge physical entity. Thereby, the digital twin model with high fidelity is established for the cable-stayed bridge. Lastly, the monitoring data of a back-stay cable of an actual bridge are adopted as the perceptual information, and the changed cable parameters are fed to the digital twin model for twin model updating and response prediction. The analyses results demonstrate that the proposed digital twin modeling method can effectively reflect the parameter changes of the actual bridge. Then the corresponding slight variations of the cable force, the tower top deviation and the mid-span deflection of the main girder are predicted by the twin model.

Keywords cable-stayed bridge; digital twins; modeling framework and principles; twin model updating; information interaction media

Full-Field Vibration of Turbine Blade Based on Single-Camera High-Speed 3D Digital Image Correlation

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Abstract A single-camera high-speed three-dimensional digital image correlation (SCHS 3D-DIC) method, which is low-cost, compact, and easy-to-implement, is adopted to test the vibration characteristics of turbine blade by using a four-mirror adapter. Firstly, the configuration and measurement principle of the SCHS 3D-DIC system are introduced. The verification test based on a cantilever aluminum plate is carried out. On this basis, the full-field vibration characteristics of the blade are tested, in order to obtain its 3D morphology, modal characteristics, full-field displacement and strain field distribution. The position and distribution characteristics of the high-strain region of the blade under vibration excitation are determined. The results show that the SCHS 3D-DIC has a higher utilization rate of field of view as compared with the conventional dual-camera 3D-DIC, which is suitable for the vibration measurement test of the slender turbine blade.

Keywords digital image correlation; turbine blade; vibration test; single high-speed camera; modal experiment

Correlation Analysis of Influence Factors for Block Vibration

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Abstract The effect of various factors on the block vibration is investigated in this paper. The peak value, variance, standard deviation, root mean square and spectrum energy obtained from wavelet packet decomposition are compared at different engine speeds, torques, oil temperatures and piston-liner clearances. The results show that the peak value of combustion fluctuates with the increase of the engine speed, and the four time domain characteristic parameters and energy of frequency bands higher than 5 increase. With the augment of engine torque, the peak value of combustion pressure, time domain characteristic parameters and energy of each frequency band arise. Under the dual action of oil damping and combustion pressure, the four time domain characteristic parameters decrease and the energy of frequency bands higher than 12 increase versus the oil temperature. With the augment of piston-liner clearance, the peak value of combustion pressure decreases due to the excessive leakage. The four time domain characteristic parameters and frequency bands higher than 5 increase, which can be attributed to the vigorous piston secondary motion.

Keywords piston-liner friction pair; block vibration signal; time domain analysis; wavelet packet decomposition; combustion status

Redundancy Control Docking Algorithm for Fuselage Based on Dynamic Programming of Position Adjustment Time

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Abstract In order to improve the docking accuracy of the middle fuselage, a fuselage redundant control docking algorithm based on the dynamic programming of position adjustment time is proposed, to ensure the docking efficiency and reduce the deformation of the supporting base plate. According to the initial position of the fuselage and the requirements of the accuracy of the fuselage docking, the target position of the fuselage is calculated; the attitude adjustment time is calculated and the attitude adjustment trajectory is planned, with attitude adjustment quantity and attitude adjustment speed as constraints. On this basis, the redundant control position adjustment algorithm of the positioner is inverse solved, by controlling the coordinated movement of the positioner to realize the position adjustment and docking of the middle fuselage. The simulated and experimental results show that the redundant control docking based on the dynamic programming of position adjustment time has no deformation of the support plate in the process of aircraft fuselage position adjustment and positioning, the docking accuracy is relatively high while the time of attitude adjustment is reduced, meeting the requirements of the coaxiality of fuselage docking.

Keyword assembly; the fuselage; pose adjustment algorithm; the simulation results; shape control

Instantaneous Frequency Identification of Time-Varying Structures Using Maximum Coefficient Based Multi-synchrosqueezing Transform

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Abstract In order to solve the problem of non-reassigned points in multi-synchrosqueezing transform and its improved algorithm, a maximum coefficient based multi-synchrosqueezing transform (MCMSST) is proposed to identify the instantaneous frequency (IF) of nonstationary response signals from time-varying structures. The Fourier spectrum is introduced at first to facilitate the selection of cut-off frequency of multi-component signals. After that, short-time Fourier transform is performed on the response signal and the estimated IF can be obtained by taking partial derivative of the Fourier coefficients with respect to time. Multiple iterations are then applied on the obtained IF and only the maximum modulus of time frequency coefficient is retained, in which extra coefficients at other positions are defined as zero. Finally, an operation of reassignment is performed on the estimated IF to get a refined IF band. Due to what the MCMSST extracts is only an IF band but not an IF curve, the maxima of time frequency coefficient modulus method is applied to extract the IF curve in the frequency band restricted by MCMSST. In addition, two numerical cases and an aluminum cantilever beam test with abrupt mass reduction are investigated to verify the effectiveness of the proposed method. The results demonstrate that the proposed MCMSST not only completely removes non-reassigned points in the refined frequency band, but also enhance the accuracy of IF identification and the robustness on noise resistance.

Keywords time-varying; multi-synchrosqueezing transform; non-reassigned point; time frequency coefficient; instantaneous frequency

In-situ Comparison Test of Vibration Reduction Effect of the Steel Spring Floating Slab Track

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Abstract In order to study the vibration reduction effect of steel spring floating slab track (SSFST) on operation line under random moving train load, a comparing in-situ test is performed at the same time on two measuring sections including regular ballastless slab track and SSFST in the same curve section of a subway line. The results indicate that: the on-line evaluation results of the vibration reduction effect of SSFST are directly related to the operation state of the train and track. The difference value ($\Delta VL_{Z,max}$) is even more than 10 dB under random dynamic excitation, and some test samples fail to meet the design requirements of special vibration reduction. In order to obtain conservative evaluation results of vibration mitigation effect, the operation section with good wheel and rail irregularity should be selected for comparing in-situ test. Through reasonable maintenance, keeping the operating trains and tracks in good operating condition is the key to meeting the vibration control requirements of the vibration-damping track sections.

Keywords steel spring floating slab track; vibration mitigation effect; train-induced vibration; metro

Lightweight Rail Fastener Fault Detection Method Based on Improved MobileVit and Grad-Cam

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Abstract In response to the challenges of the large scale of conventional deep learning networks, high hardware demands for field devices, and the intricate and labor-intensive process of manually annotating location data, this paper introduces an innovative approach to rail fastener fault detection. This method only makes semantic annotation for training data, improves the lightweight Transformer model. Further, incorporating the gradient-weighted class activation mapping (Grad-CAM) module can visualize the weight distribution of the feature map output generated by the model. This visualization provides insights into the model performance in rail fastener detection. Subsequently, the resulting activation map is binarized to precisely pinpoint and identify the target location. Experimental results demonstrate that the improved lightweight model for track fastener detection achieves an impressive accuracy rate of 94.31% in real-world railway environments.

Keywords rail fastener; intelligent fault diagnosis; deep learning; lightweight network

Vibration Energy Transfer Characteristics of the Satellite Module

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Abstract Structural sound intensity method is introduced into the field of satellite vibration transmission analysis in this paper, in order to study the vibration energy transmission law of the satellite cabin structure under the disturbance of the flywheel, and to identify the dominant transmission path and waveform. According to the equivalent plate theory, the cabin structure honeycomb panel can be equivalent and its finite element model is established. The flywheel disturbance force and torque are obtained through the force measurement platform for excitation loading, combined with the command stream for data extraction. Then, the structure sound intensity method is used to obtain the vibration energy and transfer it to the process. So, the streamline cloud diagram can be presented, and the correctness of the calculation of the vibration energy flow of the honeycomb coupling structure is verified by experiments. Through the analysis of the energy flow on the model, the transmission path from the vibration source to the camera installation area is divided. Moreover, the net transmission ratios of the different waveforms of each path and the total vibration energy are compared, and the waveform participating in the energy transmission on the different paths is analyzed, to determine the main transmission path and waveform. The results show that the total energy transmitted from the left partition to the camera area is the largest. Furthermore, the net transmission ratios of longitudinal waves in the four paths are all greater than 0.68, which are the main waveforms involved in energy transmission. In addition, the bending wave energy of the vibration source and the camera installation area is the largest, longitudinal waves, shear waves play a role in energy transfer and transformation.

Keywords satellite module; vibration energy; structural sound intensity; transmission path; vibration wave

ACO-MUSIC Two-Level Phase-Controlled Sound Source Localization Algorithm Based on Macro and Micro Guidance

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Abstract The traditional multi-signal classification (MUSIC) algorithm has a lot of computation to estimate the sound source orientation. In order to solve this problem, this paper developes a two-stage ant colony optimization (ACO) MUSIC phase-controlled sound source location algorithm based on macro and micro guidance. ACO is used to estimate the macroscopic position of sound source, and MUSIC algorithm is used to search the microcosmic orientation of the sound source. The proposed algorithm is simulated numerically, and the experimental platform is built to verify the proposed algorithm. Both results of numerical simulation and experiment show that the proposed algorithm can locate the sound source accurately and quickly. When the search step is 0.05°, the computational complexity and computation time of the proposed algorithm are only 0.25% and 2.8% of that of the traditional MUSIC algorithm.

Keywords macro and micro guidance; ant colony optimization; multiple signal classification algorithm; sound source localization algorithm

Analysis of Detectable Leakage Rate When Acoustic Wave Method is Applied to Leak Detection in Oil Pipeline

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Abstract To ensure the normal operation of the pipeline, the detection system can find the leakage in time when the pipeline leaks, and the detectable leakage rate of the acoustic wave method in the pipeline is analyzed. First, a model of acoustic wave generation and propagation attenuation is established, the attenuation property of acoustic waves in pipelines is analyzed according to the model, and the calculation method of acoustic wave attenuation amplitude at both ends of the pipeline is obtained. Second, complete ensemble empirical mode decomposition with adaptive noise (CEEMDAN) was used to decompose and reconstruct the collected signals based on mutual information optimization combined with cross spectral analysis. The experimental results show that the attenuation model can accurately estimate the attenuation amplitude of acoustic waves, and the denoising algorithm has an obvious denoising effect. Finally, the relationship between pipeline characteristics and detectable leakage rate is analyzed. The results show that the characteristics of pipelines to a certain extent determine the detectable leakage rate of the acoustic wave method, and the minimum detectable leakage rate of the acoustic wave method in pipelines can reach 0.45%. This method provides a reference for the design and layout of intelligent pipeline networks.

Keywords acoustic wave method; oil pipeline; complete ensemble empirical mode decomposition with adaptive noise (CEEMDAN); mutual information; cross-spectrum analysis; detectable leak rate

Contact Loss Identification of the Interface Between Sleeper and Track Slab for Twin-Block Slab Track

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Abstract To identify the contact loss of the interface between sleeper and track slab for twin-block slab track accurately, a finite element model of impact echo for twin-block slab track is firstly established to analyze the influence of interface damage on the propagation law of elastic waves. And concrete composite specimens with different damage positions and degrees are poured indoors, and the damage identification is carried out by using impact echo method. The results show that contact loss can significantly affect the elastic wave propagation at the interface, and the damage can be identified based on the analysis of the echo signals. The elastic wave frequency is mainly affected by the size of the excitation hammer, and the appropriate hammer should be selected according to the vulnerable structure position and theoretical calculations. The difference between the experimental thickness and the theoretical thickness of the concrete composite specimen is only 1 cm, which means the test results are reasonable. And it can be used to judge the degree of contact loss, but the damage area cannot be determined. The plane imaging technology can accurately identify the range of interface contact loss between the sleeper and the track slab, which provides a certain reference for the maintenance and repair of the twin-block

slab track structures. The test results verify the feasibility and rationality of the impact echo method used in the identification of interlayer contact loss for the twin-block tracks.

Keywords twin-block slab track; contact loss identification; impact echo method; model test; plane imaging

Probabilistic Imaging Impact Localization on Composite Stiffened Plate Based on Error Function

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Abstract A probabilistic imaging for impact localization method on composite stiffened plate structures is presented in this paper. Impact response signals are received by the sparse array piezoelectric sensor network on the surface of the composite stiffened plate. Complex Morlet wavelet transform is used to extract the narrowband Lamb wave signal of specific center frequency from the impact response signal. The Lamb wave arrival time is obtained according to the maximum modulus value of the narrowband signal. An error function is constructed based on the difference of arrival time and the probability values of each point are calculated as the impact source in the monitoring area. The probability value is used as pixel value for the probabilistic imaging for impact localization of the structure. The proposed algorithm is validated on a 700 mm × 450 mm carbon fiber reinforced composite stiffened plate. The experimental results show that the proposed algorithm is simple and effective, the imaging resolution and localization accuracy are high, and the impact localization accuracy is still considerable as using fewer sensors.

Keywords piezoelectric sensor; wavelet transform; error function; composite stiffened plate; probabilistic imaging impact localization

Analysis of the Causes of Abnormal Vibration of Reinforced Concrete Trestle

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Abstract The abnormal vibration for reinforced concrete trestles is a typical abnormal phenomenon during the operation of such projects. In order to find out the cause of the abnormal vibration and evaluate the safety of the structure, the internal and external causes that may lead to the abnormal vibration are investigated based on the combination of on-site detection and investigation, dynamic measurement and numerical simulation. Finally, the factors with high possibility are discriminated and screened, and the causes of abnormal vibration are analyzed. The research results show that the abnormal vibration of the trestle is caused by the "beat phenomenon" caused by the resonance of the second-order natural frequency and the excitation frequency of the horizontal bearing system, the small difference in the rotation speed of the idler. Among them, the pulling vibration generated by the idler on the trestle is the main factor that causes its abnormal vibration. This study provides reference value for the cause analysis of abnormal vibration of similar waterway engineering structures.

Keywords trestle; abnormal vibration; modal testing; numerical simulation; safety assessment

Evaluation Method of the Grinding Limit for Metro Rail Corrugation Considering the Rolling Noise

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Abstract Rail grinding can effectively restrain the development of rail corrugation. At present, the formulation standard of grinding limit is mainly based on vehicle running stability and driving safety, and the negative impact of wheel-rail rolling noise is paid insufficient attention to the environment in the current standard of grinding limit. To obtain the limit value of metro rail corrugation grinding under the constraint of wheel-rail rolling noise and service conditions, a comprehensive evaluation model for rail corrugation grinding limit value is established. In the model, the continuous harmonic simulation rail corrugation is taken as the system input. According to the vehicle-track coupling dynamics, the relationship between wheel-rail action force and wheel-rail surface roughness is determined. The vibration response and wheel rail rolling noise of vehicle track coupling system are analyzed and obtained, and effects of critical parameters are pointed out. Then, a prediction method of rail corrugation grinding limit for metro based on wheel-rail rolling noise is proposed. Results show that the prediction of rail corrugation grinding limit considering the influence of wheel-rail rolling noise not only meets the requirements of vehicle running stability and traffic safety, but also ensures that the noise along the metro is in a reasonable range. Based on the characteristics of wheel-rail rolling noise that are most sensitive to rail corrugation, of metro corrugation grinding limits are comprehensively evaluated and the vehicle running stability when the load changes is improved.

Keywords rail corrugation; vehicle-track coupling; wheel-rail dynamic interaction; rolling noise; grinding limit

Modal Identification of Structural Under-Sampling Based on Frequency Domain Decomposition and Resampling

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Abstract The current study investigates how to identify the structural modal for under-sampled structures. First, a resampling strategy is introduced based on the frequency domain decomposition method to identify structural modal parameters at different sampling frequencies that may suffer from aliasing. Second, a modal assurance criterion is employed for modal matching, combined with the fan-folded model, to restore the modal parameters that suffer from aliasing due to under-sampling, thereby recovering the true frequencies and damping ratios of the structure. Finally, through an 8-degree-of-freedom simulation model and an experimental case with a 4-level framework, it is demonstrated that the proposed method accurately identifies the frequencies, damping ratios, and mode shapes of under-sampled structures. Obtained results validate the correctness and feasibility of the resampling strategy, confirming that this approach effectively addresses the issue of modal identification for under-sampled structures.

Keywords modal identification; undersampling; mode aliasing; frequency domain decomposition; resampling

Electromechanical Impedance Damage Identification Method Using Singular Spectrum Analysis Under Changing Temperature Conditions

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Abstract Electromechanical impedance (EMI) damage identification technology is widely used in structural health monitoring because of its high sensitivity to local damage. However, the change of ambient temperature will shift and change the amplitude of the impedance spectrum, and even cover up the damage information of the structure, resulting in misjudgment of damage identification. To eliminate the influence of temperature variation on damage identification, singular spectrum analysis (SSA) method is used to process the impedance signal to separate the signal components which are not affected by the temperature variation. An unsupervised machine learning method combining t-distribution stochastic neighbor embedding (t-SNE) and k-means clustering algorithm is proposed to further process the signal components to realize damage identification. In order to verify the feasibility of this method, an aluminum plate connected with the bolt group is taken as the experimental object to carry out damage identification experiment of the bolt loosening using EMI under changing temperature conditions. The experimental results show that the signal component processed by SSA method can effectively identify bolt loosening under the influence of changing temperature, and the recognition accuracy of each working condition is more than 98%, which proves the effectiveness of the method in eliminating the influence of temperature variation.

Keywords damage detection; electromechanical impedance; temperature variation; singular spectrum analysis; t-distribution stochastic neighbor embedding

Ultrasonic Guided Wave Detection System for Advanced Equipment Bearing Structure

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Abstract Aiming at the problem of health monitoring of advanced equipment bearing structure, an ultrasonic guided wave detection system integrating 128 sensor channels is developed, including integrated piezoelectric intelligent layer, system host, and upper computer software with real-time damage location function. By optimizing the appearance and laminated design of the intelligent layer, improving the output power of the host, adaptively amplifying the response signal and adding crosstalk suppression circuit, the system can operate reliably in complex environment. Furthermore, different test environments are set up to verify the crosstalk suppression effect of the system, the accuracy of damage location and the stability of the signal stability under variable temperature and vibration conditions. The results show that the system can realize the stripping of crosstalk signals with different intensities. The damage location error is mm level and the damage index caused by temperature and vibration interference is one order of magnitude smaller than the damage. Therefore, the system has high stability and strong environmental adaptability which can be used as an online monitoring instrument for the health monitoring of high-end equipment bearing structures.

Keywords ultrasonic guided waves; crosstalk suppression; intelligent layer; structural health monitoring

Analysis and Experiment of Characteristics of Quasi Zero Stiffness Biomimetic Isolation Device Base on Human Foot Arches

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Abstract A biomimetic quasi zero stiffness isolation device composed of a buckling beam and viscoelastic material in parallel is proposed. It is effective in the higher precision and dynamic characteristics requirements of optical precision instruments, and it can solve the contradiction between narrow installation space and wide frequency domain isolation. A non-linear dynamic model is established for the biomimetic quasi zero stiffness isolation device, and its vibration transmission characteristics are analyzed base on harmonic balance method. The simulation accords well with the experimental results. the vibration amplitude transmission rate is less than 0.2 and the vibration amplitude transmission rate in the resonance zone of the system is also less than 0.75, which is corresponding to the frequency ratio is greater than 15. The biomimetic quasi zero stiffness isolation device effectively reduce the vibration response, this conclusion providing a reference for the design of complex isolation systems in optical precision instruments.

Keywords arches of human foot; biomimetic; vibration isolation; quasi zero stiffness

Mechanical Test and Constitutive Analysis of Internal Compression of Concrete

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Abstract In order to accurately measure the stress-strain relationship inside concrete under compression, resistance strain gauges are suggested to be placed on acrylic resin rods to measure the internal strain of concrete specimens. A large-scale micro earth pressure cell is developed to measure internal stress in concrete. Embedding the relevant testing equipment inside the concrete test specimen, the uniaxial compression test of the concrete is carried out, and the accurate stress-strain relationship data inside the concrete is obtained. The results indicate that the internal constitutive model of concrete has good ductility compared to traditional constitutive models, and the internal peak strength is much higher than traditional constitutive models. Combined with several representative concrete constitutive equations, the test is simulated by finite element method, and the stress-strain curve, peak strength and peak strain are compared and analyzed. The results show that the measured internal stress-strain curve of concrete is reasonable and accurate, and the relevant measurement methods have good accuracy and feasibility. The finite element simulation results based on Chinese design model are in good agreement with the experimental results, which can be further popularized.

Keywords concrete; internal stress-strain curve; constitutive model; sensors; peak strength; peak strain

Influence of Rolling Bearing Waviness on Gear Dynamic Transmission Error

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Abstract Gear transmission error is one of the main sources of vibration excitation in gear transmission system. It is also one of the main causes of noise. The bearing manufacturing error is an important factor affecting the vibration characteristics of gear transmission system. In order to study the influence of the manufacturing error of bearing corrugation on the dynamic transmission error of gear in the bearing-gear transmission system, a representation model of time-varying corrugation error on the raceway surface of bearing is established. A bearing-shaft-gear coupling dynamic model considering the raceway surface waviness amplitude and wave number and the time-varying gear mesh stiffness is established. The influence law of the corrugation amplitude and wave number on the dynamic transmission error of gear meshing is studied. The simulation results show that when the waviness error exists in the support bearing of input shaft, the influence of the waviness error of outer raceway on the dynamic transmission error of gear is greater than that of inner raceway. When there is waviness error of output shaft non-load bearing, the corrugation of inner and outer raceway has similar effect on the dynamic transmission error of gear. When the bearing at the load end of output shaft has the waviness error, the influence of the corrugation of outer raceway on the dynamic transmission error of gear is greater than that of inner raceway.

Keywords waviness error; roller bearing; gear meshing; dynamic model

Vibration Suppression Method for Dual-robot Collaborative Manufacturing of Weakly Rigid Components

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Abstract Multi-robot collaborative manufacturing has become an effective new way to achieve high-quality and efficient machining of large weak rigid components in aerospace. However, multiple cutting excitations acting together on weakly rigid components will generate complex machining vibrations, and result in poor manufacturing accuracy and quality. This article studies the mechanism of vibration generation, propagation and coupling under cutting excitation, and proposes a vibration suppression method for weak rigid component with dual robot collaborative machining based on machining excitation phase difference control. The simulation and experimental study is also carried out on the example of thin-walled cabin panel, which verified the correctness and effectiveness of the proposed method. The research provides a new idea for the complex vibration suppression problem of multi-robot collaborative manufacturing.

Keywords vibration suppression; dual robot; phase difference; weakly rigid components; collaborative machining

Propagation Characteristics of Acoustic Emission Signals in Stiffened Structures

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Abstract In order to study the influence of the stiffened structure on acoustic emission (AE) signal propagating, the propagation characteristics of the AE signal in the stiffened plate and the stiffened cylindrical shell are studied by theoretical calculation, numerical simulation, and experiment. Based on the proposed multi-path propagation model, the installation constraints for the sensor are derived, which can highlight the signal scattered from the stiffened structure in the time domain. On this basis, the propagation of AE signals with different frequencies in stiffened structures with different heights is numerically simulated, and the propagation characteristics of AE signals are quantitatively characterized by the constructed reflection coefficient and transmission coefficient. The accuracy of numerical simulation is verified by experiments. The results show that the AE signal will be reflected and transmitted at the stiffener, and other modes will evolve along with the modal conversion. Reflection and transmission coefficients show nonlinear characteristics with respect to the excitation frequency and the height of the stiffener. The higher the excitation frequency is, the more sensitive the reflection and transmission coefficients are to the change of the stiffener height. This study clarifies the propagation mechanism of the AE signal in the stiffened structure, and can provide specific guidance for optimizing the spatial layout of sensors in AE monitoring.

Keywords acoustic emission signal; stiffened structure; multipath propagation model; reflection; transmission

Fault Diagnosis Method for Rotating Machinery Based on Intrinsic Component Filtering

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Abstract Aiming at the challenge of weak compound fault diagnosis of rotating machinery, a novel method named intrinsic component filtering (ICF) is proposed for signature detection and separation under noisy environments norms of the rows and norms of the columns are used to achieve the sparse distribution in each sample and consistency among samples, respectively. Optimum filters are learned through minimizing the objective function. First, Hankel training matrix of the input signal is constructed, and the convolution process is simulated by the product of the weight matrix and Hankel matrix. Then, ICF is used to learn the feature matrix. The final optimum filters are determined through the Kurtosis of the trained filters. Finally, we can diagnose the fault condition using the extracted features and the corresponding envelope spectral. The simulated and experimental fault data are used to validate the performance of the proposed method. The results confirm that the proposed method can separate the weak fault components and guarantee strong robustness under strong noisy environment without any prior experience.

Keywords rotating machinery; fault diagnosis; unsupervised learning; intrinsic component filtering; weak signal detection; compound fault separation

Ultrasonic Detection of Local Delamination on Aircraft Icing Issue

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Abstract Thermal shock will lead to local fragmentation and delamination of ice on the surface of aircraft. In view of the problem that it is unavailable to acquire the information of delamination of ice at present, a non-contact detection using ultrasonic pulse-echo technology is proposed to evaluate the degree of debonding of ice. Firstly, a two-dimensional model including ultrasonic sensor, aluminum surface and ice layer is established by PZFlex software. Based on the model, the relationship between the delamination parameters and the received echo signals is analyzed. Then the evaluation method of local icing delamination is preliminarily proposed. In order to verify the feasibility of the proposed evaluation method, an experiment is performed on the experimental platform based on LabVIEW software. When the aluminum plate ice interface temperature rised from −24 ℃ to −4 ℃ under 1.6 W/cm^2, the delamination area within the detection area reach more than 62.8%. The results show that the non-contact ultrasonic pulse-echo detection can effectively evaluate the local delamination degree of ice within the detecting range ,which can provide the accurate information of ice on the swings to the deicing system.

Keywords aircraft icing; thermal shock; interface delamination; pulse-echo

Prediction and Analysis of Influence of Subway Running in Curve Section on Vibration of Gymnasium

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Abstract A refined control method for the dynamic stiffness of the floor slab at the equipment placement location is proposed to address the micro vibration control problem of the coating equipment structure floor slab in the electronic factory building. Firstly, the vibration velocity response and dynamic stiffness of the foundation floor where the coating equipment is located in the built plant are measured and analyzed, and the required dynamic stiffness of the floor under the allowable vibration standard is determined. Secondly, the dynamic finite element model of the floor structure is established to explore the difference between the structural size of the model and the calculated value of dynamic stiffness. Finally, the design size of floor structure meeting the allowable vibration standard of coating equipment is obtained through calculation, and verified by engineering. The results show that the maximum vibration velocity amplitude of 1/3 octave frequency range corresponds to the central frequency point of 40 Hz or 50 Hz under the operation state of coating equipment, and the dynamic stiffness of floor slab is the highest in the frequency range of 35.5～44.7 Hz.

Keywords Electronic workshop; coating equipment; floor structure; vibration speed; dynamic stiffness

Bridge Monitoring Data De-noise Method Based on TVFEMD-IMF Energy Entropy Increment

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Abstract Bridge monitoring data suffers from noise interference, which affects the acquisition of the true response. However, traditional empirical mode decomposition methods have limited de-noise effects. In order to enhance the de-noise effect of monitoring data, a bridge monitoring data de-noise method based on time-varying filtered empirical mode decomposition (TVFEMD) and intrinsic mode function (IMF) energy entropy increment is proposed. Firstly, the bridge monitoring data is decomposed using the TVFEMD to obtain a number of subseries. After that, the IMF energy entropy increment is used to determine the effective subsequence among several subseries. Then, the effective subsequences are recombined to achieve de-noise in the monitoring data. Finally, the effectiveness of the proposed method in terms of de-noise is evaluated using the mean absolute error (MAE), root mean square error (RMSE), and signal-noise ratio (SNR). The results of the simulation and engineering examples show that: The TVFEMD effectively solves the problem of mode mixing in the empirical mode decomposition (EMD); The combination of the TVFEMD with the IMF energy entropy increment method, which effectively suppresses the effects of multiple noise and provides significant improvements to the accuracy of the results; Compared with the EMD and the Kalman filtering methods, the MAE and the RMSE values are improved by more than 23% and 21%, respectively, which indicates that the proposed method is more effective in de-noise. The SNR value is improved by more than 38%, which demonstrates that the proposed method has superior noise immunity.

Keywords bridge; health monitoring; de-noise; time-varying filtered empirical mode decomposition; intrinsic mode function energy entropy increment

A New Method of Diagnosis Using Multi-source Heterogeneous Information Fusion in Aero-engine

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Abstract The fault equation of the whole aircraft for the three major types of parameters of gas circuit, oil circuit, and mechanical vibration mainly monitored in the actual work of the aero-engine is established, which improves the existing simple method of considering only the monitoring parameters and failure modes of a single-class engine. Under the premise of considering the monitoring parameters and failure modes of the same category, the coupling relationship between monitoring parameters of different categories and different fault modes is taken into account to achieve effective fusion of multi-source heterogeneous monitoring data and solve the problem of fine processing of differences or contradictions in the results of the same fault mode obtained by monitoring parameters of multiple engines of the same model or a single engine. A new method to improve the accuracy of engine fault diagnosis is presented.

Keywords aero-engine; multi-source heterogeneous information; data fusion; fault diagnosis