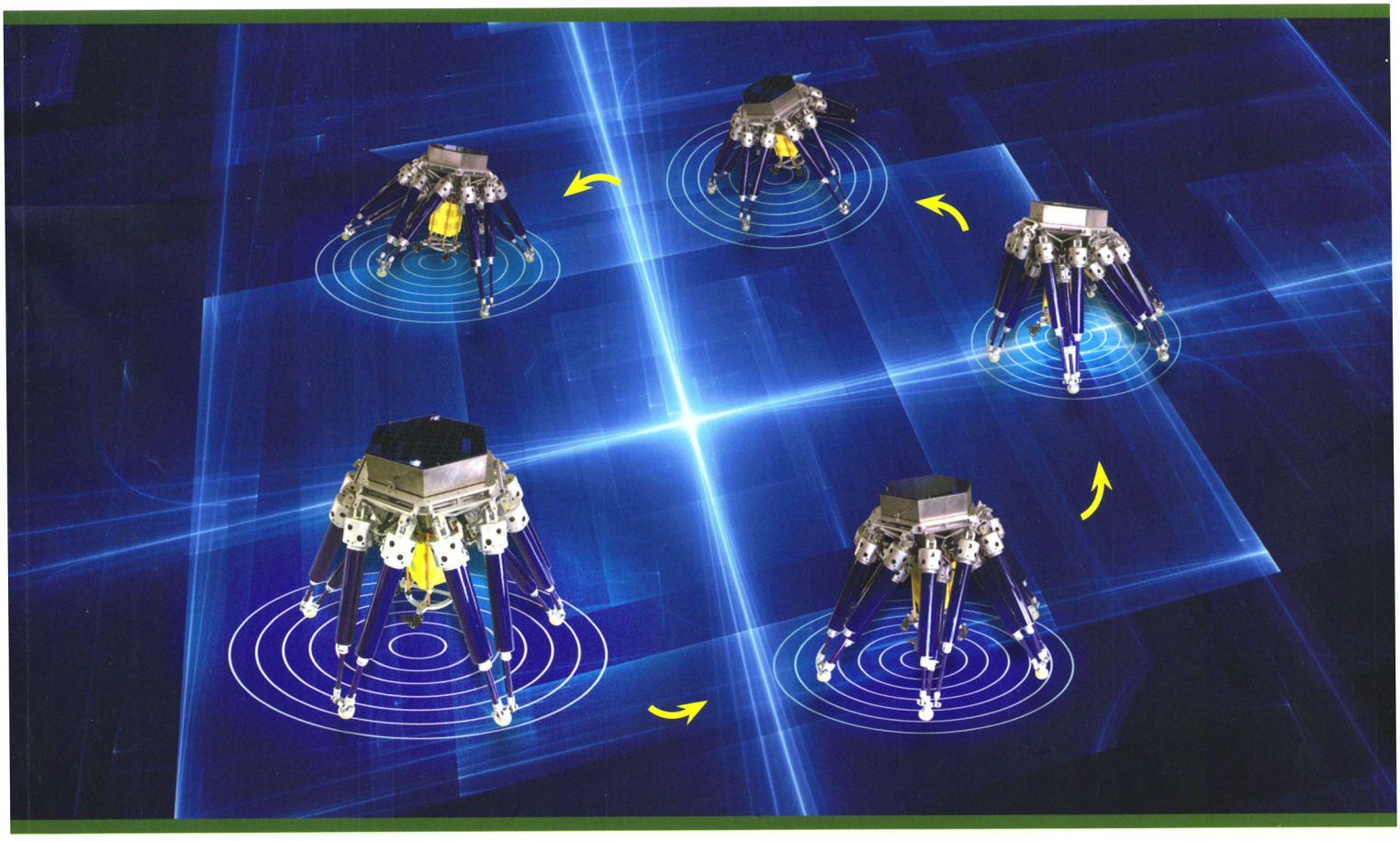
ISSN 1000-9345 QK1838768
CN 11-2737/TH · CODEN CJMEER

CHINESE JOURNAL OF MECHANICAL ENGINEERING®

中国机械工程学报



Type Design and Behavior Control for Six Legged Robots
DOI:10.1186/s10033-018-0259-9
Ling Fang and Feng Gao

CJME 2018 Vol. 31 June

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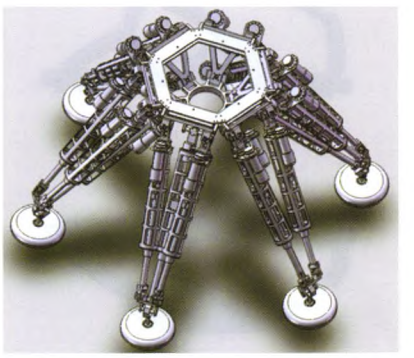
CHINESE JOURNAL OF MECHANICAL ENGINEERING

Review

DOI: 10.1186/s10033-018-0259-9

Type Design and Behavior Control for Six Legged Robots. Ling Fang • Feng Gao

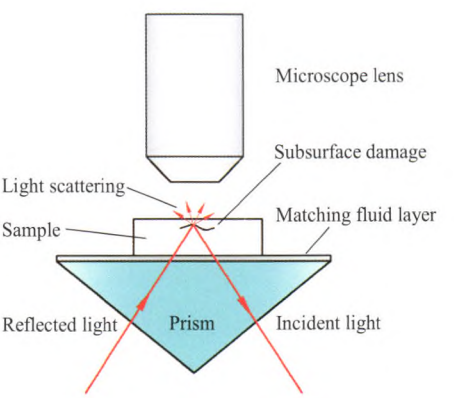
Abstract: The research on legged robots attracted much attention both from the academia and industry. Legged robots are multi-input multi-output with multiple end-effector systems. Therefore, the mechanical design and control framework are challenging issues. This paper reviews the development of type synthesis and behavior control on legged robots; introduces the hexapod robots developed in our research group based on the proposed type synthesis method. The control framework for legged robots includes data driven layer, robot behavior layer and robot execution layer. Each layer consists several components which are explained in details. Finally, various experiments were conducted on several hexapod robots. The summarization of the type synthesis and behavior control design constructed in this paper would provide a unified platform for communications and references for future advancement for legged robots.



DOI: 10.1186/s10033-018-0229-2

Methods for Detection of Subsurface Damage: A Review.
Jing-fei Yin • Qian Bai • Bi Zhang

Abstract: Subsurface damage is easily induced in machining of hard and brittle materials because of their particular mechanical and physical properties. It is detrimental to the strength, performance and lifetime of a machined part. To manufacture a high quality part, it is necessary to detect and remove the machining induced subsurface damage by the subsequent processes. However, subsurface damage is often covered with a smearing layer generated in a machining process, it is rather difficult to directly observe and detect by optical microscopy. An efficient detection of subsurface damage directly leads to quality improvement and time saving for machining of hard and brittle materials. This paper presents a review of the methods for detection of subsurface damage, both destructive and non-destructive. Although more reliable, destructive methods are typically time-consuming and confined to local damage information. Non-destructive methods usually suffer from uncertainty factors, but may provide global information on subsurface damage distribution. These methods are promising because they can provide a capacity of rapid scan and detection of subsurface damage in spatial distribution.

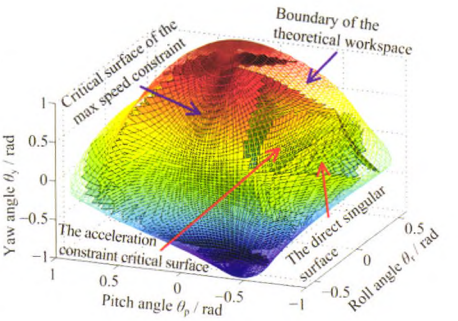


Mechanism and Robotics

DOI: 10.1186/s10033-018-0253-2

Parameter Optimization of a Stability-Training Platform's 4-PSS/PS Parallel Mechanism Based on Training Ability Evaluation Index and PSO Algorithm.
Wei-Guo Wu • Li-Yang Gao

Abstract: The existing mechanism parameter optimization (MPO) method of parallel mechanisms only considers the workspace size and ignores contribution of each configuration's performance. So a novel MPO method is proposed for our serial-parallel mechanism platform, which is used in stability training of legged robots. Regarding the platform's parallel mechanism part, a 4-PSS/PS parallel mechanism, two object functions and three constraint conditions are defined to establish the MPO model. The first object function uses critical motion indexes of the moving platform. The second one uses derivative function of the defined disturbance Lagrange function. After analyzing stability-training requirements of five existing legged robots, requirements of the platform's motion capability are given out. Regarding each proposed object function separately, the MPO model is solved by the particle swarm optimization (PSO) algorithm. Valid workspace boundaries corresponding to the optimization results are solved by a numerical method. The overall optimal solution is determined based on volume of the valid workspace. It is revealed that the two object functions result in similar optimization solutions, which shows that the proposed object functions can reflect the stability-training ability consistently. This paper proposes and verifies the established MPO model, which considers both the workspace size and configurations' performance evaluation.



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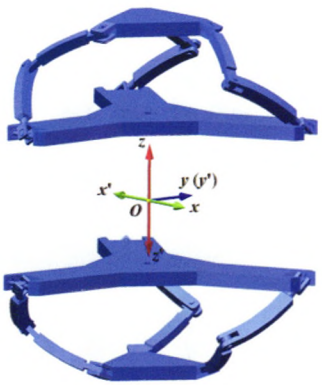
DOI: 10.1186/s10033-018-0256-z

Design and Analysis for a Three-Rotational-DOF Flight Simulator of Fighter-Aircraft.

Chang-Chun Zhou • Yue-Fa Fang

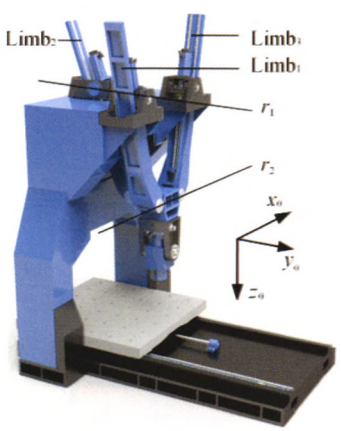


Abstract: Most of researchers focused on traditional six degrees of freedom (DOF) Stewart flight simulator, which can not be adaptive in fighter-aircraft flight simulator. A three rotational DOF flight simulator of fighter-aircraft based on double parallel manipulator and hybrid structure is presented. The flight simulator is composed of two identical 3-RRS (revolute-revolute-spherical) spherical parallel manipulators and one cabin, called Twins. The cabin has an additional independent DOF for 360° continuous rotation, so it can be applied as a flight simulator for a fighter–aircraft to achieve spin maneuvering. Because of the introduction of the hybrid structure and double parallel manipulator of the mechanism, the redundancy exists with respect to both kinematics and actuation. Kinematics is carried out and Jacobian matrix is established by means of screw theory. The inverse kinematics is given out by the analytical method. 64 groups inverse solutions are showed in a table by permutation. Forward kinematics is solved by an effectively numerical method. The forward numerical method is realized based on the analytically inverse kinematics and Jacobian matrix. The numerical examples show that the forward numerical method can be used in real-time control. The rolling motion is considered in forward kinematics and a numerical example is given out. The proposed flight simulator can spin and there are three rotational DOF with a hybrid structure so that the novel flight simulator can be used in the field of the fighter-aircraft for pilots to train.

DOI: 10.1186/s10033-018-0251-4

Analysis and Optimization of a Spatial Parallel Mechanism for a New 5-DOF Hybrid Serial-Parallel Manipulator.

Dong-Sheng Zhang • Yun-Dou Xu • Jian-Tao Yao • Yong-Sheng Zhao



Abstract: Hybrid manipulators have potentially application in machining industries and attract extensive attention from many researchers on the basis of high stiffness and high dexterity. Therefore, in order to expand the application prospects of hybrid manipulator, a novel 5-degree-of-freedom (DOF) hybrid serial-parallel manipulator (HSPM) is proposed. Firstly, the design plan of this manipulator is introduced. Secondly, the analysis of this manipulator is carried out in detail, including kinematics analysis, statics analysis, and workspace analysis. Especially, an amplitude equivalent method of disposing the over-constrained force/couple to the non-overconstrained force/couple is used in the statics analysis. Then, three performance indices are used to optimize the PM. Two of them have been widely used, and the third one is a new index which considers the characteristics of the actuated force. Based on the performance indices, the performance atlas is drawn and the optimal design of the PM is investigated. In order to satisfy the anticipant kinetic characteristics of the PM, the verification of the optimized physical dimension is done and the workspace based on the optimized physical dimension is carried out. This paper will lay good theoretical foundations for application of this novel HSPM and also can be applied to other hybrid manipulators.

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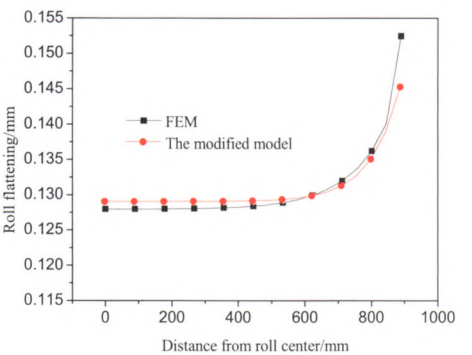
Intelligent Manufacturing Technology

DOI: 10.1186/s10033-018-0246-1

Modification of Roll Flattening Analytical Model Based on the Plane Assumption. Tao Wang • Qing-Xue Huang • Hong Xiao • Xiang-Dong Qi

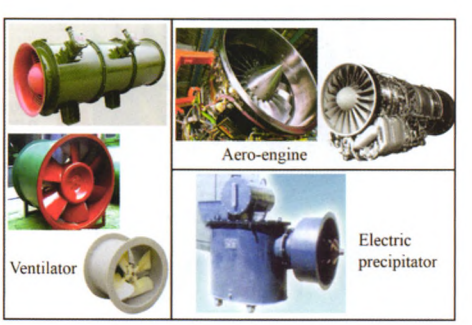
Abstract: Roll flattening is an important component in the roll stack elastic deformation, which has important influence on controlling of the strip crown and flatness. Foppl formula and semi-infinite body model are the most popular analytical models in the roll flattening calculation. However, the roll flattening calculated by traditional flattening models has a great deviation from actual situation, especially near the barrel edges. Therefore, in order to improve the accuracy of roll flattening, a new model is proposed based on the elastic half plane theory. The calculation formulas of roll flattening are deduced respectively under the assumptions of plane strain and plane stress. Then, the two assumptions are combined through the method of introducing an transition coefficient, and the distribution rules of roll flattening for different rolling force, flattening width, roll length and roll diameter are analyzed by using the FEM analysis software Marc. Regarding the ratio of the length to roll end and the roll diameter as variable to fit the transition coefficient, the new model of roll flattening is established based on the elastic half plane theory. Finally, the transition coefficient is fitted to establish the model. Compared with the traditional models, the new model can effectively improve the calculation deviation in the roll end, which has important significance for accurate simulation of plate shape, especially for the distribution of rolling force between rolls.



DOI: 10.1186/s10033-018-0254-1

Plastic Deformation Mechanism in Double-Roller Clamping Spinning of Flanged Thin-Walled Cylinder. Shu-Qin Fan • Sheng-Dun Zhao • Chao Chen

Abstract: Double-roller clamping spinning (DRCS) is a new process for forming a thin-walled cylinder with a complex surface flange. The process requires a small spinning force, and can visibly improve forming quality and production efficiency. However, the deformation mechanism of the process has not been completely understood. Therefore, both a finite element numerical simulation and experimental research on the DRCS process are carried out. The results show that both radial force and axial force dominate the forming process of DRCS. The deformation area elongates along the radial direction and bends along the axial direction under the action of the two forces. Both the outer edge and round corner of the flange show the tangential tensile stress and radial compressive stress. The middle region shows tensile tangential stress and radial stress, while the inner edge shows compressive tangential stress and radial stress. Tangential tensile strain causes a wall thickness reduction in the outer edge and middle regions of the flange. The large compressive thickness strain causes material accumulation and thus, an increase in the wall thickness of the round corner. Because of bending deformation, the round corner shows a large radial tensile strain in addition. The inner edge of the flange shows small radial compressive strain and tensile strain in thickness. Thus, the wall thickness on the inner edge of the flange continues to increase, although the increment is small. Furthermore, microstructure analysis and tensile test results show that the flanged thin-walled cylinder formed by DRCS has good mechanical properties. The results provide instructions for the application of the DRCS process.



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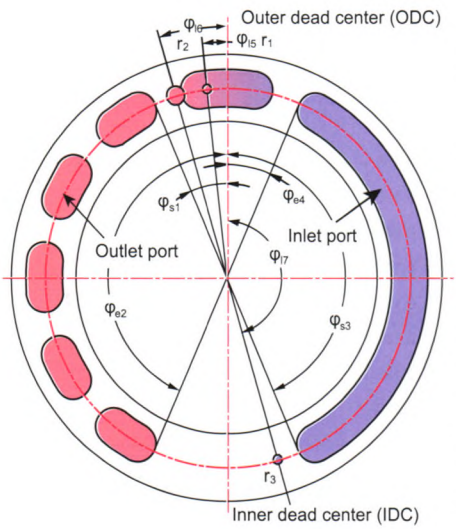
DOI: 10.1186/s10033-018-0258-x

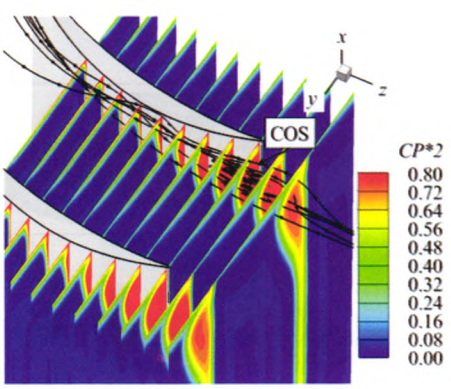
Noise Reduction of an Axial Piston Pump by Valve Plate Optimization. Shao-Gan Ye • Jun-Hui Zhang • Bing Xu



Abstract: Current researches mainly focus on the investigations of the valve plate utilizing pressure relief grooves. However, air-release and cavitation can occur near the grooves. The valve plate utilizing damping holes show excellent performance in avoiding air-release and cavitation. This study aims to reduce the noise emitted from an axial piston pump using a novel valve plate utilizing damping holes. A dynamic pump model is developed, in which the fluid properties are carefully modeled to capture the phenomena of air release and cavitation. The causes of different noise sources are investigated using the model. A comprehensive parametric analysis is conducted to enhance the understanding of the effects of the valve plate parameters on the noise sources. A multi-objective genetic algorithm optimization method is proposed to optimize the parameters of valve plate. The amplitudes of the swash plate moment and flow rates in the inlet and outlet ports are defined as the objective functions. The pressure overshoot and undershoot in the piston chamber are limited by properly constraining the highest and lowest pressure values. A comparison of the various noise sources between the original and optimized designs over a wide range of pressure levels shows that the noise sources are reduced at high pressures. The results of the sound pressure level measurements show that the optimized valve plate reduces the noise level by 1.6 dB(A) at the rated working condition. The proposed method is effective in reducing the noise of axial piston pumps and contributes to the development of quieter axial piston machines.

DOI: 10.1186/s10033-018-0247-0

Influence of Endwall Boundary Layer Suction on the Flow Fields of a Critically Loaded Diffusion Cascade. Zhi-Yuan Cao • Bo Liu • Ting Zhang



Abstract: Boundary layer suction is an effective method used to delay separations in axial compressors. Most studies on boundary layer suction have focused on improving the performance of compressors, whereas few studies investigated the influence on details of the flow fields, especially vortexes in compressors. CFD method is validated with experimental data firstly. Three single-slot and one double-slot endwall boundary layer suction schemes are designed and investigated. In addition to the investigation of aerodynamic performance of the cascades with and without suction, variations in corner open separation, passage vortex, and concentration shedding vortex, which are rarely seen for the flow controlled blades in published literatures, are analyzed. Then, flow models, which are the ultimate aim, of both baseline and aspirated cascades are established. Results show that single-slot endwall suction scheme adjacent to the suction surface can effectively remove the corner open separation. With suction mass flow rate of 0.85%, the overall loss coefficient and endwall loss coefficient of the cascade are reduced by 25.2% and 48.6%, respectively. Besides, this scheme increases the static pressure rise coefficient of the cascade by 3.2% and the flow turning angle of up to 3.3° at 90% span. The concentration shedding vortex decreases, whereas the passage vortex increases. For single-slot suction schemes near the middle pitchwise of the passage, the concentration shedding vortex increases and the passage vortex is divided into two smaller passage vortexes, which converge into a single-passage vortex near the trailing edge section of the cascade. For the double-slot suction scheme, triple-passage vortexes are presented in the blade passage. Some new vortex structures are discovered, and the novel flow models of aspirated compressor cascade are proposed, which are important to improve the design of multi-stage aspirated compressors.

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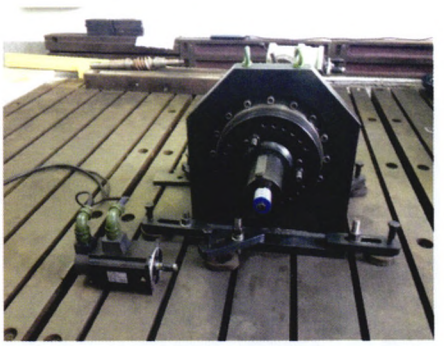
DOI: 10.1186/s10033-018-0249-y

Response Sensitivity to Design Parameters of RV Reducer.

Yu-Hu Yang • Chuan Chen • Shi-Yu Wang

Abstract: Dynamic characteristic significantly affects performance of RV reducer. The current researches mainly pay attention to free vibration properties of RV reducer. In order to satisfy the increasing demand on high performance, response sensitivity is analytically studied on the basis of cyclic symmetry structure. Based on the structure characteristics, a dynamic model is developed by taking into account the influence of bearing stiffness, crankshaft bending stiffness and mesh stiffness within planetary and cycloidal stages. For the model, governing equation of motion is derived and solved by Fourier series method. The solution revealed that forced vibrations at primary frequency are well defined structural. There exist three typical forced vibration modes: rotational, translational and planetary component modes. Response sensitivity to basic design parameters is obtained as closed-form expressions by differential method. With the typical vibration modes, response sensitivity is simplified and classified into three types. Calculation of sensitivity implies that vibrations of the output wheel are sensitive to eccentricity. As eccentricity increases, sensitivity of translation decreases first and then increases, but sensitivity of rotation always increases. The proposed method for analyzing response sensitivity provides some principles for selecting parameters for RV reducer from the point of view of forced vibration.

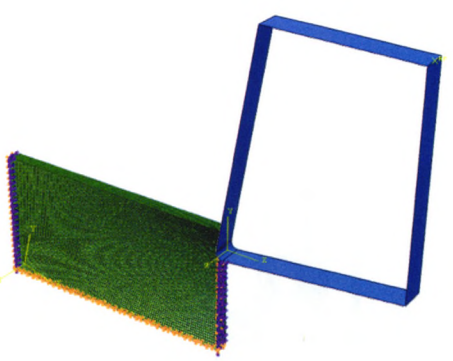


DOI: 10.1186/s10033-018-0250-5

3D Progressive Damage Based Macro-Mechanical FE Simulation of Machining Unidirectional FRP Composite.

Yan-Li He • Joao-Paulo Davim • Hong-Qian Xue

Abstract: Finite element (FE) simulation is a powerful tool for investigating the mechanism of machining fiber-reinforced polymer composite (FRP). However in existing FE machining simulation works, the two-dimensional (2D) progressive damage models only describe material behavior in plane stress, while the three-dimensional (3D) damage models always assume an instantaneous stiffness reduction pattern. So the chip formation mechanism of FRP under machining is not fully analyzed in general stress state. A 3D macro-mechanical based FE simulation model was developed for the machining of unidirectional glass fiber reinforced plastic. An energy based 3D progressive damage model was proposed for damage evolution and continuous stiffness degradation. The damage model was implemented for the Hashin-type criterion and Maximum stress criterion. The influences of the failure criterion and fracture energy dissipation on the simulation results were studied. The simulated chip shapes, cutting forces and sub-surface damages were verified by those obtained in the reference experiment. The simulation results also show consistency with previous 2D FE models in the reference. The proposed research provides a model for simulating FRP material behavior and the machining process in 3D stress state.



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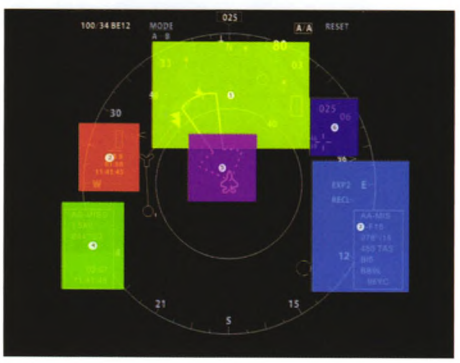
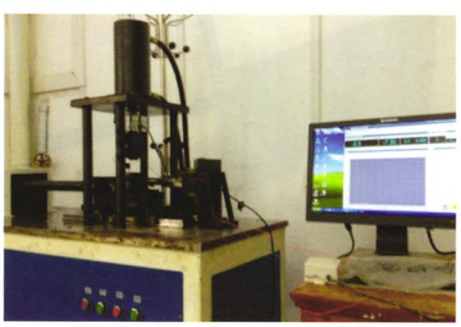


DOI: 10.1186/s10033-018-0245-2

An Experimental Study of Features Search under Visual Interference in Radar Situation-Interface. Xiao-Li Wu • Jing Li • Feng Zhou

Abstract: As was found through information interface analysis of target search in fighter radar situation environment, there are many of visual attention problems caused by complex environment and features, which generate visual interference. This paper extracts the interference environment of situation interface and the feature of information matter as the major factors, also and adopts the interference environment, featured items and quantity as three variables to conduct the experimental study on simulation of the feature search fighter information identification. The experimental results showed that the information identification under low and high interference environments revealed to a significant difference. Due to the high interference environment formed by various information presented in the radar situation-interface, only if being forcibly free from interference could the pilots be able to realize the information identification precisely. Three features, i.e., regular shape-single color, irregular shape-single color and irregular shape-hybrid color, presented a trend of progressive increase of reaction time, which suggested that irregular shape-hybrid color was the difficult cognition and the long reaction time. The eye movement data also suggested that the target search under high interference environment displayed the longer fixation time, more saccade counts and longer scan path, than under low interference environment. In addition, the first saccade time, the total fixation time and saccade counts of featured items search presented an increasing trend, which is the same as reaction. Therefore, the colors and shapes of featured items exerted a remarkable influence to the judgment of objects target. In conclusion the interference environment and the information matter features both have played the important roles in influence of the information identification in the radar situation-interface. The environment and the features are the design factors, which needed for consideration in the information layout of the complex situation-interface. Thus, a conclusion provides a design guideline to the rational layout and improvement of the complex information interface.



DOI: 10.1186/s10033-018-0252-3

Experimental Study on Wear Performance and Oil Film Characteristics of Surface Textured Cylinder Liner in Marine Diesel Engine.

Zhi-Wei Guo • Cheng-Qing Yuan • Xiu-Qin Bai • Xin-Ping Yan

Abstract: It is of a vital importance to reduce the frictional losses in marine diesel engines. Advanced surface textures have provided an effective solution to friction performance of rubbing pairs due to the rapid development of surface engineering techniques. However, the mechanisms through which textured patterns and texturing methods prove beneficial remains unclear. To address this issue, the tribological system of the cylinder liner-piston ring (CLPR) is investigated in this work. Two types of surface textures (Micro concave, Micro V-groove) are processed on the cylinder specimen using different processing methods. Comparative study on the friction coefficients, worn surface texture features and oil film characteristics are performed. The results demonstrate that the processing method of surface texture affect the performance of the CLPR pairs under the specific testing conditions. In addition the micro V-groove processed by CNCPM is more favorable for improving the wear performances at the low load, while the micro-concave processed by CE is more favorable for improving the wear performances at the high load. These findings are in helping to understand the effect of surface texture on wear performance of CLPR.

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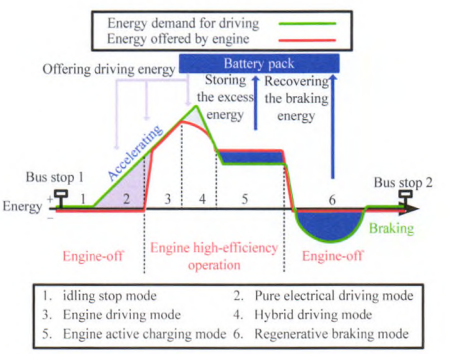
Advanced Transportation Equipment

DOI: 10.1186/s10033-018-0257-y

City-Bus-Route Demand-based Efficient Coupling Driving Control for Parallel Plug-in Hybrid Electric Bus.

Qin-Pu Wang • Chao Yang • Ya-Hui Liu • Yuan-Bo Zhang

Abstract: Recently, plug-in hybrid electric bus has been one of the energy-efficient solutions for urban transportation. However, the current vehicle efficiency is far from optimum, because the unpredicted external driving conditions are difficult to be obtained in advance. How to further explore its fuel-saving potential under the complicated city bus driving cycles through an efficient control strategy is still a hot research issue in both academic and engineering area. To realize an efficient coupling driving operation of the hybrid powertrain, a novel coupling driving control strategy for plug-in hybrid electric bus is presented. Combined with the typical feature of a city-bus-route, the fuzzy logic inference is employed to quantify the driving intention, and then to determine the coupling driving mode and the gear-shifting strategy. Considering the response deviation problem in the execution layer, an adaptive robust controller for electric machine is designed to respond to the transient torque demand, and instantaneously compensate the response delay and the engine torque fluctuation. The simulations and hard-in-loop tests with the actual data of two typical driving conditions from the real-world city-bus-route are carried out, and the results demonstrate that the proposed method could guarantee the hybrid powertrain to track the actual torque demand with 10.4% fuel economy improvement. The optimal fuel economy can be obtained through the optimal combination of working modes. The fuel economy of plug-in hybrid electric bus can be significantly improved by the proposed control scheme without loss of drivability.

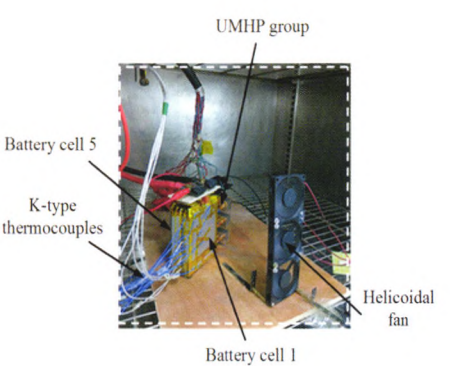


DOI: 10.1186/s10033-018-0255-0

Experimental Investigation on Cooling/Heating Characteristics of Ultra-Thin Micro Heat Pipe for Electric Vehicle Battery Thermal Management.

Fei-Fei Liu • Feng-Chong Lan • Ji-Qing Chen • Yi-Gang Li

Abstract: Due to the heat pipes' transient conduction, phase change and fluid dynamics during cooling/heating with high frequency charging/discharging of batteries, it is crucial to investigate in depth the experimental dynamic thermal characteristics in such complex heat transfer processes for more accurate thermal analysis and design of a BTMS. In this paper, the use of ultra-thin micro heat pipe (UMHP) for thermal management of a lithium-ion battery pack in EVs is explored by experiments to reveal the cooling/heating characteristics of the UMHP pack. The cooling performance is evaluated under different constant discharging and transient heat inputs conditions. And the heating efficiency is assessed under several sub-zero temperatures through heating films with/without UMHPs. Results show that the proposed UMHP BTMS with forced convection can keep the maximum temperature of the pack below 40℃ under 1~3C discharging, and effectively reduced the instant temperature increases and minimize the temperature fluctuation of the pack during transient federal urban driving schedule (FUDS) road conditions. Experimental data also indicate that heating films stuck on the fins of UMHPs brought about adequate high heating efficiency comparing with that stuck on the surface of cells under the same heating power, but has more convenient maintenance and less cost for the BTMS. The experimental dynamic temperature characteristics of UMHP which is found to be a high-efficient and low-energy consumption cooling/heating method for BTMSs, can be performed to guide thermal analysis and optimization of heat pipe BTMSs.



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DOI: 10.1186/s10033-018-0248-z

Reliability Assessment for the Solenoid Valve of a High-Speed Train Braking System under Small Sample Size.

Jian-Wei Yang • Jin-Hai Wang • Qiang Huang • Ming Zhou

Abstract: Reliability assessment of the braking system in a high-speed train under small sample size and zero-failure data is very important for safe operation. Traditional reliability assessment methods are only performed well under conditions of large sample size and complete failure data, which lead to large deviation under conditions of small sample size and zero-failure data. To improve this problem, a new Bayesian method is proposed. Based on the characteristics of the solenoid valve in the braking system of a high-speed train, the modified Weibull distribution is selected to describe the failure rate over the entire lifetime. Based on the assumption of a binomial distribution for the failure probability at censored time, a concave method is employed to obtain the relationships between accumulation failure probabilities. A numerical simulation is performed to compare the results of the proposed method with those obtained from maximum likelihood estimation, and to illustrate that the proposed Bayesian model exhibits a better accuracy for the expectation value when the sample size is less than 12. Finally, the robustness of the model is demonstrated by obtaining the reliability indicators for a numerical case involving the solenoid valve of the braking system, which shows that the change in the reliability and failure rate among the different hyperparameters is small. The method is provided to avoid misleading of subjective information and improve accuracy of reliability assessment under conditions of small sample size and zero-failure data.

CHINESE JOURNAL OF MECHANICAL ENGINEERING

中国机械工程学报

(Bimonthly, Started in 1988)

Vol. 31, June 2018

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Sponsored by	Chinese Mechanical Engineering Society
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ISSN 1000-9345

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