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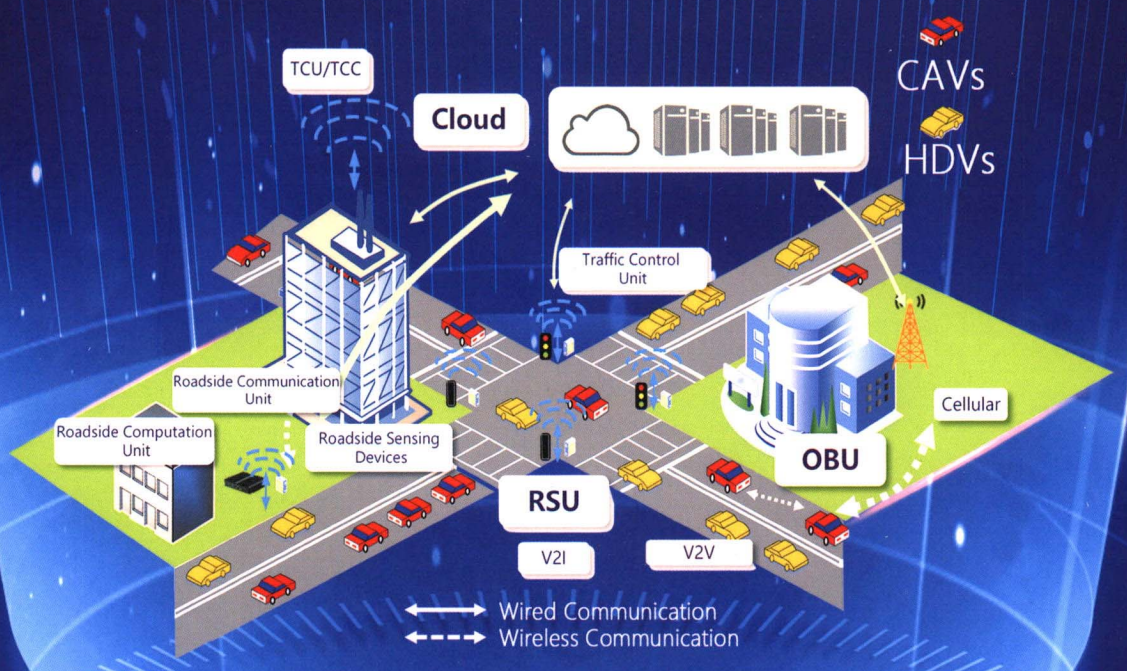

Special Issue on Key Technologies in Connected Autonomous Electrified Vehicles
Guest Editors: Yugong Luo, Wenbo Chu and Dongpu Cao

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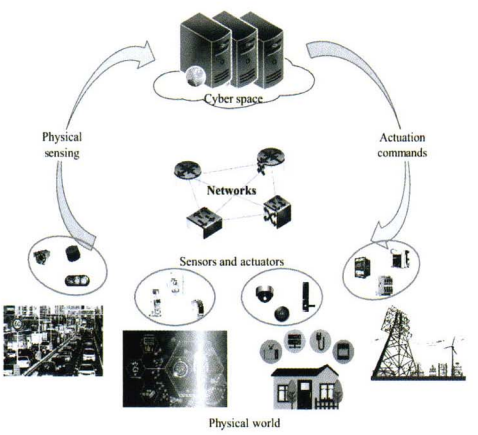
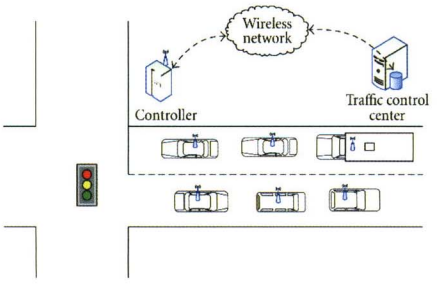
Vol.34, No.5, October, 2021

CHINESE JOURNAL OF MECHANICAL ENGINEERING

Special Issue on Key Technologies in Connected Autonomous Electrified Vehicles





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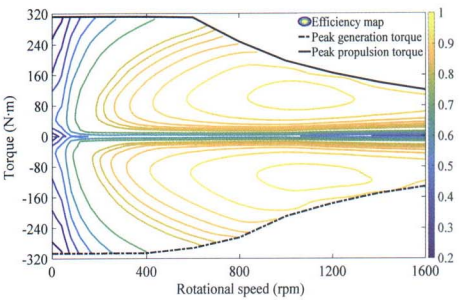
Vol.34, No.5, October, 2021

(2021)34:83

DOI: 10.1186/s10033-021-00601-3

Abstract: Most researches focus on the regenerative braking system design in vehicle components control and braking torque distribution, few combine the connected vehicle technologies into braking velocity planning. If the braking intention is accessed by the vehicle-to-everything communication, the electric vehicles (EVs) could plan the braking velocity for recovering more vehicle kinetic energy. Therefore, this paper presents an energy-optimal braking strategy (EOBS) to improve the energy efficiency of EVs with the consideration of shared braking intention. First, a double-layer control scheme is formulated. In the upper-layer, an energy-optimal braking problem with accessed braking intention is formulated and solved by the distance-based dynamic programming algorithm, which could derive the energy-optimal braking trajectory. In the lower-layer, the nonlinear time-varying vehicle longitudinal dynamics is transformed to the linear time-varying system, then an efficient model predictive controller is designed and solved by quadratic programming algorithm to track the original energy-optimal braking trajectory while ensuring braking comfort and safety. Several simulations are conducted by jointing MATLAB and CarSim, the results demonstrated the proposed EOBS achieves prominent regeneration energy improvement than the regular constant deceleration braking strategy. Finally, the energy-optimal braking mechanism of EVs is investigated based on the analysis of braking deceleration, battery charging power, and motor efficiency, which could be a guide to real-time control.



(2021)34:88

DOI: 10.1186/s10033-021-00597-w

Abstract: This paper presents a novel neural-fuzzy-based adaptive sliding mode automatic steering control strategy to improve the driving performance of vision-based unmanned electric vehicles with time-varying and uncertain parameters. Primarily, the kinematic and dynamic models which accurately express the steering behaviors of vehicles are constructed, and in which the relationship between the look-ahead time and vehicle velocity is revealed. Then, in order to overcome the external disturbances, parametric uncertainties and time-varying features of vehicles, a neural-fuzzy-based adaptive sliding mode automatic steering controller is proposed to supervise the lateral dynamic behavior of unmanned electric vehicles, which includes an equivalent control law and an adaptive variable structure control law. In this novel automatic steering control system of vehicles, a neural network system is utilized for approximating the switching control gain of variable structure control law, and a fuzzy inference system is presented to adjust the thickness of boundary layer in real-time. The stability of closed-loop neural-fuzzy-based adaptive sliding mode automatic steering control system is proven using the Lyapunov theory. Finally, the results illustrate that the presented control scheme has the excellent properties in term of error convergence and robustness.

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(2021)34:117

DOI: 10.1186/s10033-021-00630-y

Surrounding Objects Detection and Tracking for Autonomous Driving Using LiDAR and Radar Fusion

Ze Liu • Yingfeng Cai • Hai Wang • Long Chen

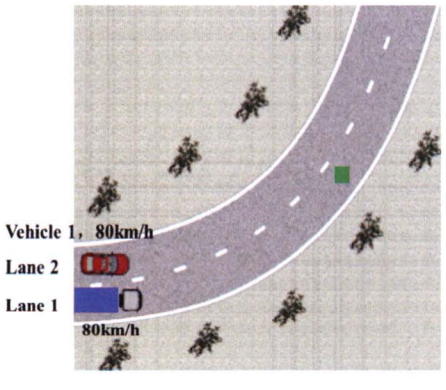
Abstract: Radar and LiDAR are two environmental sensors commonly used in autonomous vehicles, Lidars are accurate in determining objects' positions but significantly less accurate as Radars on measuring their velocities. However, Radars relative to Lidars are more accurate on measuring objects velocities but less accurate on determining their positions as they have a lower spatial resolution. In order to compensate for the low detection accuracy, incomplete target attributes and poor environmental adaptability of single sensors such as Radar and LiDAR, in this paper, an effective method for high-precision detection and tracking of surrounding targets of autonomous vehicles. By employing the Unscented Kalman Filter, Radar and LiDAR information is effectively fused to achieve high-precision detection of the position and speed information of targets around the autonomous vehicle. Finally, the real vehicle test under various driving environment scenarios is carried out. The experimental results show that the proposed sensor fusion method can effectively detect and track the vehicle peripheral targets with high accuracy. Compared with a single sensor, it has obvious advantages and can improve the intelligence level of autonomous cars.

(2021)34:87

DOI: 10.1186/s10033-021-00605-z

Rollover Prevention and Motion Planning for an Intelligent Heavy Truck

Zhilin Jin • Jingxuan Li • Hong Wang • Jun Li • Chaosheng Huang



Abstract: It is very necessary for an intelligent heavy truck to have the ability to prevent rollover independently. However, it was rarely considered in intelligent vehicle motion planning. To improve rollover stability, a motion planning strategy with autonomous anti rollover ability for an intelligent heavy truck is put forward in this paper. Considering the influence of unsprung mass in the front axle and the rear axle and the body roll stiffness on vehicle rollover stability, a rollover dynamics model is built for the intelligent heavy truck. From the model, a novel rollover index is derived to evaluate vehicle rollover risk accurately, and a model predictive control algorithm is applicated to design the motion planning strategy for the intelligent heavy truck, which integrates the vehicle rollover stability, the artificial potential field for the obstacle avoidance, the path tracking and vehicle dynamics constrains. Then, the optimal path is obtained to meet the requirements that the intelligent heavy truck can avoid obstacles and drive stably without rollover. In addition, three typical scenarios are designed to numerically simulate the dynamic performance of the intelligent heavy truck. The results show that the proposed motion planning strategy can avoid collisions and improve vehicle rollover stability effectively even under the worst driving scenarios.

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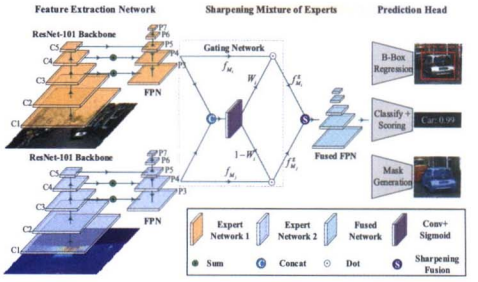
DOI: 10.1186/s10033-021-00602-2

Adaptive Multi-modal Fusion Instance Segmentation for CAEVs in Complex Conditions: Dataset, Framework and Verifications

Pai Peng • Keke Geng • Guodong Yin • Yanbo Lu • Weichao Zhuang • Shuaipeng Liu

Abstract: Current works of environmental perception for connected autonomous electrified vehicles (CAEVs) mainly focus on the object detection task in good weather and illumination conditions, they often perform poorly in adverse scenarios and have a vague scene parsing ability. This paper aims to develop an end-to-end sharpening mixture of experts (SMoE) fusion framework to improve the robustness and accuracy of the perception systems for CAEVs in complex illumination and weather conditions. Three original contributions make our work distinctive from the existing relevant literature. The Complex KITTI dataset is introduced which consists of 7481 pairs of modified KITTI RGB images and the generated LiDAR dense depth maps, and this dataset is fine annotated in instance-level with the proposed semi-automatic annotation method. The SMoE fusion approach is devised to adaptively learn the robust kernels from complementary modalities. Comprehensive comparative experiments are implemented, and the results show that the proposed SMoE framework yield significant improvements over the other fusion techniques in adverse environmental conditions. This research proposes a SMoE fusion framework to improve the scene parsing ability of the perception systems for CAEVs in adverse conditions.



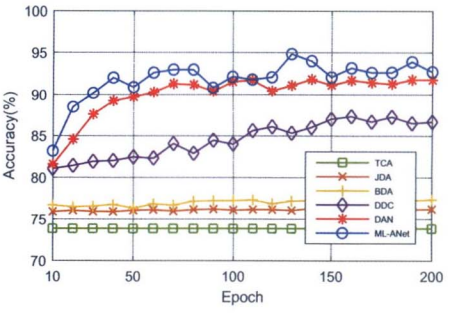
(2021)34:78

DOI: 10.1186/s10033-021-00598-9

ML-ANet: A Transfer Learning Approach Using Adaptation Network for Multi-label Image Classification in Autonomous Driving

Guofa Li • Zefeng Ji • Yunlong Chang • Shen Li • Xingda Qu • Dongpu Cao

Abstract: To reduce the discrepancy between the source and target domains, a new multi-label adaptation network (ML-ANet) based on multiple kernel variants with maximum mean discrepancies is proposed in this paper. The hidden representations of the task-specific layers in ML-ANet are embedded in the reproducing kernel Hilbert space (RKHS) so that the mean-embeddings of specific features in different domains could be precisely matched. Multiple kernel functions are used to improve feature distribution efficiency for explicit mean embedding matching, which can further reduce domain discrepancy. Adverse weather and cross-camera adaptation examinations are conducted to verify the effectiveness of our proposed ML-ANet. The results show that our proposed ML-ANet achieves higher accuracies than the compared state-of-the-art methods for multi-label image classification in both the adverse weather adaptation and cross-camera adaptation experiments. These results indicate that ML-ANet can alleviate the reliance on fully labeled training data and improve the accuracy of multi-label image classification in various domain shift scenarios.



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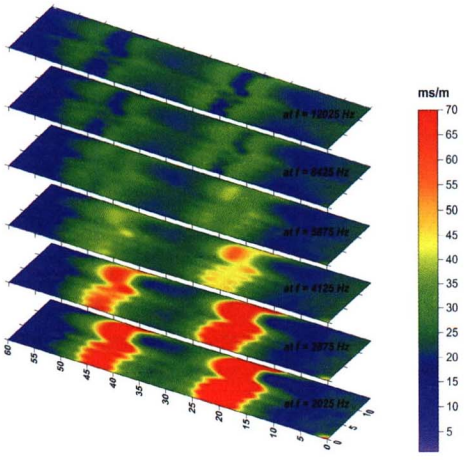
Review

(2021)34:97
DOI: 10.1186/s10033-021-00613-z

Current Trends and Perspectives of Detection and Location for Buried Non-metallic Pipelines

Liang Ge • Changpeng Zhang • Guiyun Tian • Xiaoting Xiao • Junaid Ahmed • Guohui Wei • Ze Hu • Ju Xiang • Mark Robinson

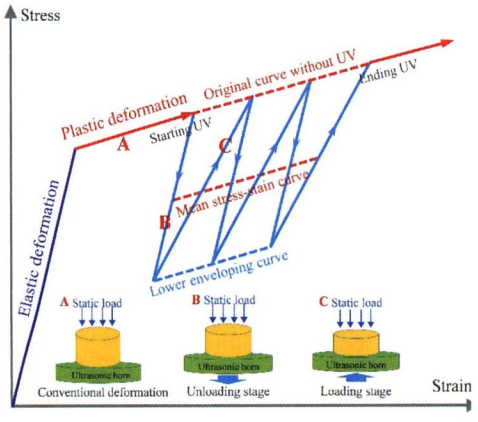


Abstract: Buried pipelines are an essential component of the urban infrastructure of modern cities. Traditional buried pipes are mainly made of metal materials. With the development of material science and technology in recent years, non-metallic pipes, such as plastic pipes, ceramic pipes, and concrete pipes, are increasingly taking the place of pipes made from metal in various pipeline networks such as water supply, drainage, heat, industry, oil, and gas. The location technologies for the location of the buried metal pipeline have become mature, but detection and location technologies for the non-metallic pipelines are still developing. In this paper, current trends and future perspectives of detection and location of buried non-metallic pipelines are summarized. Initially, this paper reviews and analyzes electromagnetic induction technologies, electromagnetic wave technologies, and other physics-based technologies. It then focuses on acoustic detection and location technologies, and finally introduces emerging technologies. Then the technical characteristics of each detection and location method have been compared, with their strengths and weaknesses identified. The current trends and future perspectives of each buried non-metallic pipeline detection and location technology have also been defined. Finally, some suggestions for the future development of buried non-metallic pipeline detection and location technologies are provided.

(2021)34:99
DOI: 10.1186/s10033-021-00612-0

A Review on Ultrasonic-Assisted Forming: Mechanism, Model, and Process

Guangda Shao • Hongwei Li • Mei Zhan



Abstract: Compared with conventional forming processes, ultrasonic-assisted forming technology with a high frequency and small amplitude can significantly improve the forming quality of materials. Owing to the advantages of reduced forming force, improved surface quality, avoidance of forming defects, and strengthened surface structure, ultrasonic-assisted forming technology has been applied to increasingly advanced forming processes, such as incremental forming, spinning, and micro-forming. However, in the ultrasonic-assisted forming process, there are multiple ultrasonic mechanisms, such as the volume effect and surface effect. The explanation of the effect of ultrasonic vibration (UV) on plastic deformation remains controversial, hindering the development of related technologies. Recently, many researchers have proposed many new theories and technologies for ultrasonic-assisted forming. To summarize these developments, systematic discussions on mechanisms, theoretical models, and forming performances are provided in this review. On this basis, the limitations of the current study are discussed. In addition, an outlook for ultrasonic-assisted forming is proposed: efficient and stable UV systems, difficulty forming components with complex geometry, explanation of the in-depth mechanism, a systematic theoretical prediction model, and multi-field-coupling energy-assisted forming are considered to be hot spots in future studies. The present review enhances existing knowledge of ultrasonic-assisted forming, and facilitates a fast reference for related researchers.

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Mechanism and Robotics

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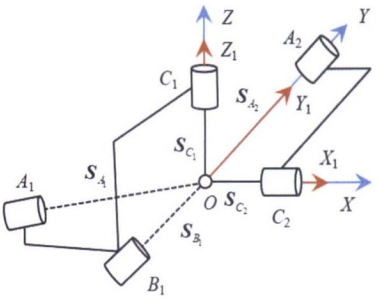
DOI: 10.1186/s10033-021-00610-2

Generalized Kinematics Analysis of Hybrid Mechanisms Based on Screw Theory and Lie Groups Lie Algebras

Peng Sun • Yanbiao Li • Ke Chen • Wentao Zhu • Qi Zhong • Bo Chen

Abstract: Advanced mathematical tools are used to conduct research on the kinematics analysis of hybrid mechanisms, and the generalized analysis method and concise kinematics transfer matrix are obtained. In this study, first, according to the kinematics analysis of serial mechanisms, the basic principles of Lie groups and Lie algebras are briefly explained in dealing with the spatial switching and differential operations of screw vectors. Then, based on the standard ideas of Lie operations, the method for kinematics analysis of parallel mechanisms is derived, and Jacobian matrix and Hessian matrix are formulated recursively and in a closed form. Then, according to the mapping relationship between the parallel joints and corresponding equivalent series joints, a forward kinematics analysis method and two inverse kinematics analysis methods of hybrid mechanisms are examined. A case study is performed to verify the calculated matrices wherein a humanoid hybrid robotic arm with a parallel-series-parallel configuration is considered as an example. The results of a simulation experiment indicate that the obtained formulas are exact and the proposed method for kinematics analysis of hybrid mechanisms is practically feasible.

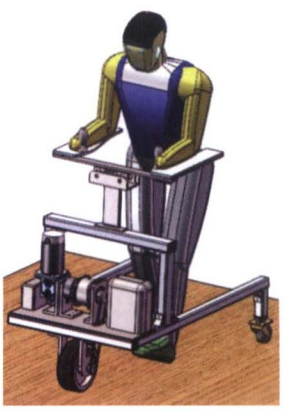


(2020)34:100
DOI: 10.1186/s10033-021-00618-8

Robotic Walker for Slope Mobility Assistance with Active-Passive Hybrid Actuator

Junqiang Li • Lei Zhao • Tiejun Li

Abstract: Walking assistance can be realized by active and passive robotic walkers when their users walk on even roads. However, fast signal processing and real-time control are necessary for active robotic walkers when the users walk on slopes, while assistive forces cannot be provided by passive robotic walkers when the users walk uphill. A robotic walker with an active-passive hybrid actuator (APHA) was developed in this study. The APHA, which consists of a rotary magnetorheological (MR) brake and a DC motor, can provide mobility assistance to users walking both uphill and downhill via the cooperative operation of the MR brake and DC motor. The rotary MR brake was designed with a T-shaped configuration, and the system was optimized to minimize the brake volume. Prototypes of the APHA and robotic walker were constructed. A control algorithm for the robotic walker was developed based on the characteristics of the APHA and the structure of the robotic walker. The mechanical properties of the APHA were characterized, and experiments were conducted to evaluate the mobility assistance supplied by the robotic walker on different roads. The results show that the APHA can meet the requirements of the robotic walker, and suitable assistive forces can be provided by the robotic walker, which has a simple mechanical structure and control method.



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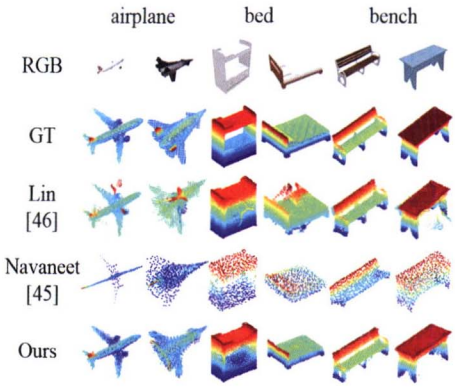
Intelligent Manufacturing Technology

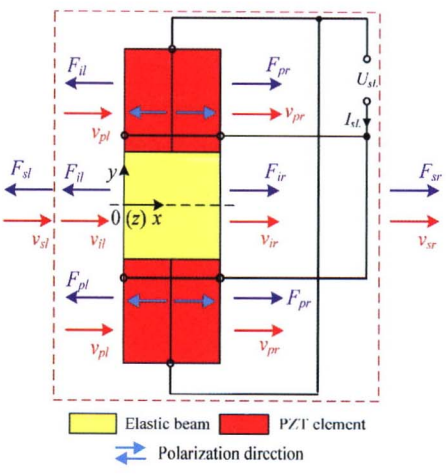


(2021)34:93
DOI: 10.1186/s10033-021-00615-x

Weakly-Supervised Single-view Dense 3D Point Cloud Reconstruction via Differentiable Renderer

Peng Jin • Shaoli Liu • Jianhua Liu • Hao Huang • Linlin Yang • Michael Weinmann • Reinhard Klein

Abstract: In recent years, addressing ill-posed problems by leveraging prior knowledge contained in databases on learning techniques has gained much attention. In this paper, we focus on complete three-dimensional (3D) point cloud reconstruction based on a single red-green-blue (RGB) image, a task that cannot be approached using classical reconstruction techniques. For this purpose, we used an encoder-decoder framework to encode the RGB information in latent space, and to predict the 3D structure of the considered object from different viewpoints. The individual predictions are combined to yield a common representation that is used in a module combining camera pose estimation and rendering, thereby achieving differentiability with respect to imaging process and the camera pose, and optimization of the two-dimensional prediction error of novel viewpoints. Thus, our method allows end-to-end training and does not require supervision based on additional ground-truth (GT) mask annotations or ground-truth camera pose annotations. Our evaluation of synthetic and real-world data demonstrates the robustness of our approach to appearance changes and self-occlusions, through outperformance of current state-of-the-art methods in terms of accuracy, density, and model completeness.



(2021)34:101
DOI: 10. 10.1186/s10033-021-00623-x

Novel Traveling Wave Sandwich Piezoelectric Transducer with Single Phase Drive: Theoretical Modeling, Experimental Validation, and Application Investigation

Liang Wang • Fushi Bai • Viktor Hofmann • Jiamei Jin • Jens Twiefel

Abstract: Most of traditional traveling wave piezoelectric transducers are driven by two phase different excitation signals, leading to a complex control system and seriously limiting their applications in industry. To overcome these issues, a novel traveling wave sandwich piezoelectric transducer with a single-phase drive is proposed in this study. Traveling waves are produced in two driving rings of the transducer while the longitudinal vibration is excited in its sandwich composite beam, due to the coupling property of the combined structure. This results in the production of elliptical motions in the two driving rings to achieve the drive function. An analytical model is firstly developed using the transfer matrix method to analyze the dynamic behavior of the proposed transducer. Its vibration characteristics are measured and compared with computational results to validate the effectiveness of the proposed analytical model. Besides, the driving concept of the transducer is investigated by computing the motion trajectory of surface points of the driving ring and the quality of traveling wave of the driving ring. Additionally, application example investigations on the driving effect of the proposed transducer are carried out by constructing and assembling a tracked mobile system. Experimental results indicated that 1) the assembled tracked mobile system moved in the driving frequency of 19410 Hz corresponding to its maximum mean velocity through frequency sensitivity experiments; 2) motion characteristic and traction performance measurements of the system prototype presented its maximum mean velocity with 59 mm/s and its maximum stalling traction force with 1.65 N, at the excitation voltage of 500 V_{RMS}. These experimental results demonstrate the feasibility of the proposed traveling wave sandwich piezoelectric transducer.

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DOI: 10.1186/s10033-021-00616-w

Investigation into the Independent Metering Control Performance of a Twin Spools Valve with Switching Technology-controlled Pilot Stage

Qi Zhong • Huiming Bao • Yanbiao Li • Haocen Hong • Bin Zhang • Huayong Yang

Abstract: In hydraulic area, independent metering control (IMC) technology is an effective approach to improve system efficiency and control flexibility. In addition, digital hydraulic technology (DHT) has been verified as a reasonable method to optimize system dynamic performance. Integrating these two technologies into one component can combine their advantages together. However, few works focused on it. In this paper, a twin spools valve with switching technology-controlled pilot stage (TSVSP) is presented, which applied DHT into its pilot stage while appending IMC into its main stage. Based on this prototype valve, a series of numerical and experiment analysis of its IMC performance with both simulated load and excavator boom cylinder are carried out. Results showed fast and robust performance of pressure and flow compound control with acceptable fluctuation phenomenon caused by switching technology. Rising time of flow response in excavator cylinder can be controlled within 200 ms, meanwhile, the recovery time of rod chamber pressure under suddenly changed condition is optimized within 250 ms. IMC system based on TSVSP can improve both dynamic performance and robust characteristics of the target actuator so it is practical in valve-cylinder system and can be applied in mobile machineries.

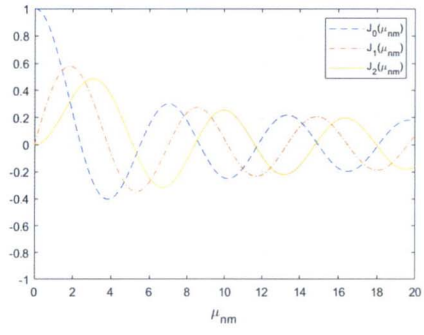
(2021)34:89

DOI: 10.1186/s10033-021-00609-9

Oscillation Modes of Weld Pool in Stationary GTA Welding Using Structure Laser Method

Xingpei Wu • Jiankang Huang • Jing He • Shien Liu • Guangyin Liu • Ding Fan

Abstract: Researchers have recently attempted to monitor pool oscillations using the three-dimensional laser vision method. However, the deficiency of simulation software will result in significant capital expenditure. Both simulations and experiments are performed in this study, and the Bessel equation is used to analyze the oscillation mode of a weld pool. The laser dot matrix images of (0, 1), (1, 1), (2, 1), and (0, 2) oscillation modes at different times are obtained via structured laser optical measurement simulation. The oscillation mode of a stationary gas tungsten arc weld pool is analyzed based on laser dot matrix images obtained from a structure laser experiment. Results show that the simulated laser dot matrix images are consistent with the experiment results. The oscillation mode of the weld pool can be recognized based on the laser dot matrix image. This study not only provides conditions for assessing the penetrating state of a weld pool, but also enable a further understanding of the oscillation mode of a weld pool and the development of more effective observation methods and measurement tools to effectively control and improve welding quality.



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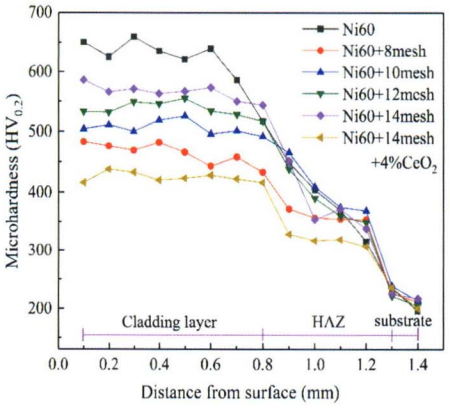
Smart Materials

(2021)34:92
DOI: 10.1186/s10033-021-00599-8

Study of Cracking Mechanism and Wear Resistance in Laser Cladding Coating of Ni-based Alloy

Zhenglei Yu • Lunxiang Li • Deqiang Zhang • Guangfeng Shi • Guang Yang • Zezhou Xu • Zhihui Zhang

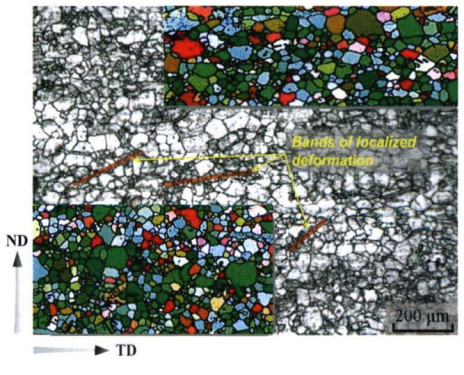


Abstract: Nickel-based alloy coatings were widely used for the remanufacturing of dies and moulds by laser cladding, but the crack sensitivity would be increase due to the higher strength and hardness, which reduced the wear resistance of Ni-based alloys. In this paper, Ni-based coatings with the addition of a plastic phase(an austenitic stainless net) were prepared using laser cladding technology, and the CeO_2 was added in cladding layers. The cracking mechanism, microhardness, microstructure, phase composition, and wear properties were investigated. The relationship between thermal stress and the elastic and plastic fracture had been developed from the standpoint of fracture mechanics and thermal elastic fracture mechanics. The fracture criterion of the nickel-based coating was obtained, and the study has shown that the crack sensitivity could be reduced by decreasing the thermal expansion coefficient $\Delta\alpha$. Thus, a new method was proposed, which the stainless steel nets were prefabricated on the substrate. It was found that the number of cracks reduced significantly with the addition of stainless steel net. When the stainless steel net with 14 mesh was added in Ni-based coatings, the average microhardness of nickel composite coating was 565 $HV_{0.2}$, which was 2.6 times higher than that of the 45 steel substrate. Although the rare earth oxide 4 wt.% CeO_2 and stainless steel net were added in the Ni-based coating reducing the microhardness (the average microhardness is 425 $HV_{0.2}$), the wear resistance of it improved substantially. The wear volume of Ni-based composite coating was 0.56×10^{-5} $mm^3{\cdot}N^{-1}{\cdot}m^{-1}$, which was 85.1% lower than that of 45 steel. The experiment results have shown that the Nickel-based composite coating is equipped with low crack sensitivity and high abrasive resistance with austenitic stainless net and the rare earth oxide 4 wt.% CeO_2. This research offers an efficient solution to produce components with low crack susceptibility and high wear-resistance coatings fabricated by laser cladding.

(2021)34:95
DOI: 10.1186/s10033-021-00608-w

Variation in Deformation Behaviors along the Transverse Direction during the Warm Rolling of a 1480-mm-Wide AZ31B Plate

Chenchen Zhi • Lifeng Ma • Weitao Jia • Pengtao Liu • Qichi Le • Zhiquan Huang • Tingzhuang Han



Abstract: A decrease in the weight of aerospace vehicles, large ships, weapons, and high-speed trains will increase the demand for wide-width magnesium alloy plates and their composite parts to replace steel and plastic. An investigation was conducted to study the variation in deformation behaviors along the transverse direction during the warm rolling of a 1480-mm-wide AZ31B plate. A uniaxial thermal compression test with a 59 % reduction was performed at different positions on a 13.7-mm-thick rolled plate along the width direction at a temperature of 220 °C and 270 °C and strain rate of 15 s^{-1}. At the same time, the 13.7-mm-thick plate was rolled in a single pass to 5.6 mm on a mill with a 1725-mm-wide roll to confirm the thermal deformation behavior and the dynamic recrystallization (DRX). The results show that the main texture type does not change and the grain size does not have a clear deflection when the magnesium alloy plate reaches a certain value under rolling accumulative reduction. The grain size of a 13.7-mm-thick plate increases with a decrease in the distance to the center layer in the thickness direction. In the width direction, the edge (R6) first decreases and then increases toward the symmetric plane (R1). The critical stress required for dynamic recrystallization in the transition zone R3 of the rolled plate width is minimum, and the average grain size is minimum owing to the relatively complete recrystallization.

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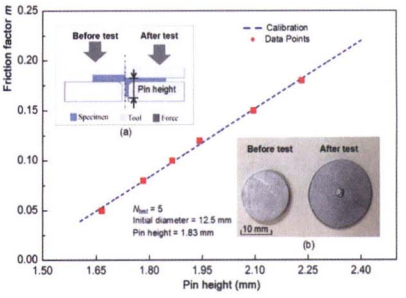
DOI: 10.1186/s10033-021-00664-2

Sheet Bulk Forming of Thin-Walled Components with External Gearing through Upsetting Using Controllable Deformation Zone Method

Xincun Zhuang • Meile Liang • Shengfa Zhu • Yin Zhu • Zhen Zhao

Abstract: Sheet-bulk metal forming (SBMF) is a promising process for manufacturing complex sheet components with functional elements. In this study, the entire forming process for a typical thin-walled component with external gearing is investigated, including sheet forming and bulk forming processes. Deep drawn cups are prepared during sheet forming; subsequently, upsetting is performed on the sidewall to form external gearing. The upsetting method performed is known as upsetting with a controllable deformation zone (U-CDZ). Compared with the conventional upsetting method, a floating counter punch with a counter force is used in the U-CDZ method such that the forming mechanism is changed into the accumulation of the deformation zone instead of deformation throughout the entire sidewall. The effects of the counter force and material flow are investigated to understand the mechanism. The forming quality, i.e., the formfilling and effective strain distribution, improved, whereas a high forming load is avoided. In addition, a punch with a lock bead is used to prevent folding at the inner corner during the experiment.



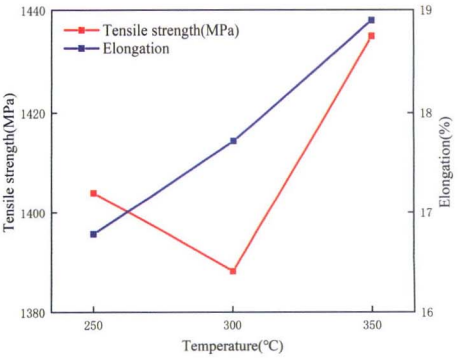
(2021)34:113

DOI: 10.1186/s10033-021-00634-8

Effect of Deformation on Microstructure and Mechanical Properties of Medium Carbon Steel during Heat Treatment Process

Yan Peng • Caiyi Liu • Ningning Wang

Abstract: The current research of the Q-P and Q-P-T process has been focused on controlling the heating temperature and holding time, or adding alloy elements into the steel to induce precipitation strengthening and improve the strength and plasticity of the steel. In this article, based on a quenching-partitioning-tempering (Q-P-T) process combined with a hot deformation technology, a deforming-quenching-partitioning-tempering (D-Q-P-T) process was applied to medium carbon steel. The effect of the heat treatment parameters on the microstructure and mechanical properties of experimental steel under deformation was studied. Through use of a scanning electron microscope (SEM), transmission electron microscopy (TEM) and tensile tests, the optimal heat treatment conditions for realizing high strength and plasticity that meet the safety requirements were obtained. The mechanism for the D-Q-P-T process to improve the strength and plasticity of experimental steel was discussed. A multiphase composite structure of lath martensite and retained austenite was obtained. Compared with the Q-P-T process, use of the D-Q-P-T process can increase the strength of steel by 57.77 MPa and the elongation by 5%. This study proposes a method to improve the strength and plasticity of steel.



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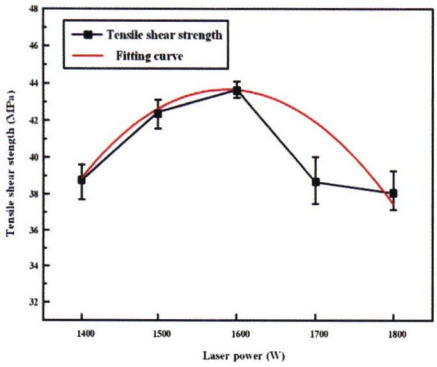
(2021)34:134
DOI: 10.1186/s10033-021-00645-5

Effect of Surface Texture on Tensile Shear Strength of 1060Al-PET Welding Joints

Jia Liu • Yuchi Dai • Yan Shi • Wenfu Cui • Tao Jiang



Abstract: Joining metal to plastic can lighten weight of products to reduce energy consumption. However, it is difficult to achieve high-strength welding between metal and plastic. To address this problem, the methods of surface texture pretreatment and laser irradiation welding was proposed to achieve the high-strength connection of metal and plastic. In this study, with different parameters of laser power and texture morphology, 1060 Al with surface texture treatment was joined to polyethylene terephthalate (PET) by laser irradiation welding from metal side. Study showed that as the laser power increased, the tensile shear strength of joints increased first, and decreased thereafter. Tensile shear tests demonstrated that the mechanical force of joint was strengthened contributed to mechanical anchorage formed by surface texture. The depth-width ratio of the texture grooves affected the tensile shear process of the joint. According to the result of temperature simulation, the existence of texture grooves reduced the heat transfer efficiency, and the heat dissipation at interface was also impeded in course of laser welding. Finally, the maximum tensile strength of 1060Al-PET joint reached 48.4 MPa, which was close to the strength of PET matrix. The bonding mechanism of the 1060Al-PET joints was composed of mechanical bonding and chemical bonding. This study proposes an effective method to join metal to plastic which achieved high-strength connection between metal and plastic.

Advanced Transportation Equipment

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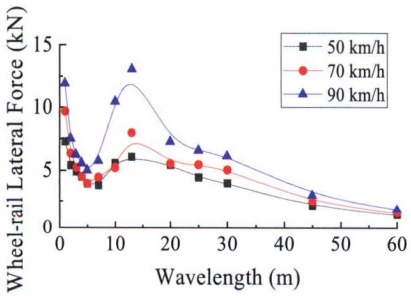
DOI: 10.1186/s10033-021-00614-y

Subway Embedded Track Geometric Irregularity Safety Limits

Yuxiang Zhang • Jian Han • Huilai Song • Yu Liu



Abstract: A coupling dynamic model of a subway train and an embedded track is established to study the safety limits of track irregularities. The simulated vehicle system was a 74-degrees of freedom multi-rigid body model, and the rail was a Timoshenko beam. The slab was a three-dimensional solid finite element model. The sensitive wavelength irregularity was first studied, and then the safety limit of the sensitive wavelength was analyzed. The wheel-rail lateral force exhibited a substantial effect on the track alignment and gauge irregularity safety limit. The wheel-rail vertical force and the rate of wheel load reduction significantly affected the height and cross-level irregularity safety limit. The results demonstrate that the safety limits of the alignment, gauge, height, and cross-level embedded track geometric irregularity are 5.3 mm, [−10.5, 8] mm, 5.6 mm, and 6 mm, respectively.

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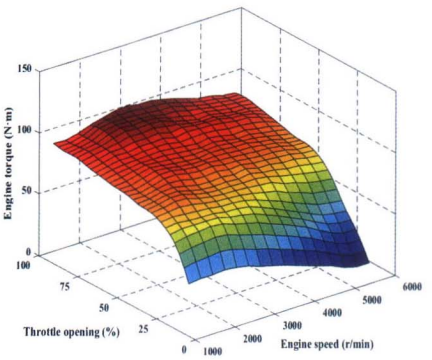
(2021)34:102

DOI: 10.1186/s10033-021-00620-0

Optimization Transmission Efficiency with Driver Intention for Automotive Continuously Variable Transmission under Slip Mode

Ling Han • Hui Zhang • Ruoyu Fang • Hongxiang Liu

Abstract: This study proposes and experimentally validates an optimal integrated system to control the automotive continuously variable transmission (CVT) by Model Predictive Control (MPC) to achieve its expected transmission efficiency range. The control system framework consists of top and bottom layers. In the top layer, a driving intention recognition system is designed on the basis of fuzzy control strategy to determine the relationship between the driver intention and CVT target ratio at the corresponding time. In the bottom layer, a new slip state dynamic equation is obtained considering slip characteristics and its related constraints, and a clamping force bench is established. Innovatively, a joint controller based on model predictive control (MPC) is designed taking internal combustion engine torque and slip between the metal belt and pulley as optimization dual targets. A cycle is attained by solving the optimization target to achieve optimum engine torque and the input slip in real-time. Moreover, the new controller provides good robustness. Finally, performance is tested by actual CVT vehicles. Results show that compared with traditional control, the proposed control improves vehicle transmission efficiency by approximately 9.12%–9.35% with high accuracy.



(2021)34:108

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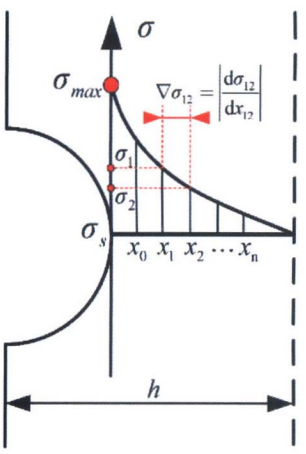
Fatigue Characterization on a Cast Aluminum Beam of a High-Speed Train Through Numerical Simulation and Experiments

Weiyuan Dou • Lele Zhang • Haifeng Chang • Haifeng Zhang • Changqing Liu

Abstract: The cast aluminum beam is a key structure for carrying the body-hung traction motor of a high-speed train; its fatigue property is fundamental for predicting the residual life and service mileage of the structure. To characterize the structural fatigue property, a finite element-based method is developed to compute the stress concentration factor,which is used to obtain the structural fatigue strength reduction factors. A full-scale fatigue test on the cast aluminum beam is designed and implemented for up to ten million cycles, and the corresponding finite element model of the beam is validated using the measured data of the gauges. The results show that the maximum stress concentration occurs at the fillet of the supporting seat, where the structural fatigue strength reduction factor is 2.45 and the calculated fatigue limit is 35.4 MPa. Moreover, no surface cracks are detected using the liquid penetrant test. Both the experimental and simulation results indicate that the cast aluminum beam can satisfy the service life requirements under the designed loading conditions.



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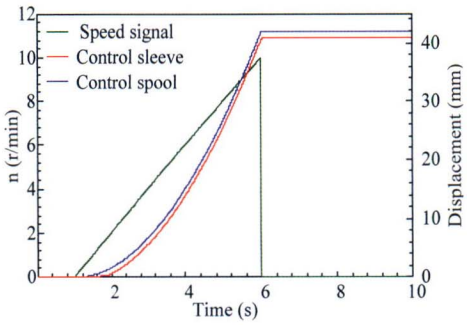
Vol.34, No.5, October, 2021

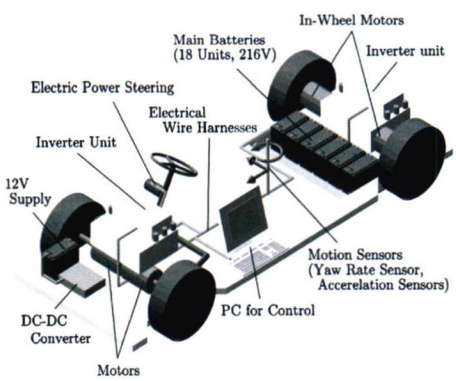
(2021)34:106
DOI: 10.1186/s10033-021-00627-7

Influence of Novel Redirector with Bypass Damping on the Performance of Load-Sensing Steering System

Yuqi Wang • Xinhui Liu • Jinshi Chen • Dongyang Huo



Abstract: Load-sensing steering systems for articulated loaders are prone to large pressure shocks and oscillations during steering operations, affecting the system stability. An optimized structure of the redirector with bypass damping is proposed to improve this phenomenon. In this structure, orifices and throttle grooves are added to the traditional redirector. To control the steering load and working conditions, the steering load of the loader is replaced by a pressure regulating valve. Simulation and experimental results reveal that the redirector with bypass damping has better load-sensing characteristics than the traditional redirector. The peak output pressure shock caused by the load unit step signal decreases from 6.50 to 5.64 MPa, which means the pressure oscillation of the hydraulic system is reduced by 13.4%. The pressure fluctuation time can be reduced from 2.09 to 1.6 s, with a decrease rate of 23.4%. The output pressure oscillation decays swiftly, and the smoothness of the steering operation is improved significantly.



(2021)34:125
DOI: 10.1186/s10033-021-00642-8

Optimal Design for Anti-Skid Control of Electric Vehicles by Fuzzy Approach

Chenming Li • Han Zhao • Kang Huang • Ye-Hwa Chen

Abstract: In this paper, a new fuzzy approach is applied to optimal design of the anti-skid control for electric vehicles. The anti-skid control is used to maintain the wheel speed when there are uncertainties. The control is able to provide an appropriate torque for wheels when the vehicle is about to skid. The friction coefficient and the moments of inertia of wheels and motor are considered as uncertain parameters. These nonlinear, bounded and time-varying uncertainties are described by fuzzy set theory. The control is deterministic and is not based on IF-THEN fuzzy rules. Then, the optimal design for this fuzzy system and control cost is proposed by fuzzy information. In this way, the uniform boundedness and uniform ultimate boundedness are guaranteed and the average fuzzy performance is minimized. Numerical simulations show that the control can prevent vehicle skidding with the minimum control cost under uncertainties.

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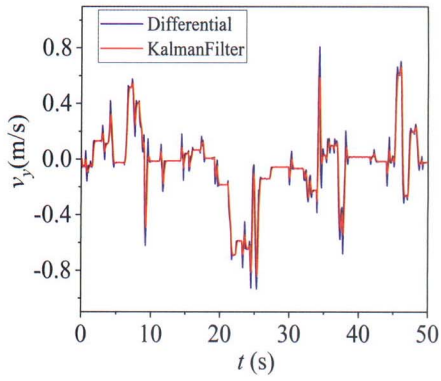
(2021)34:135

DOI: 10.1186/s10033-021-00650-8

Target Vehicle Selection Algorithm for Adaptive Cruise Control Based on Lane-changing Intention of Preceding Vehicle

Jun Yao • Guoying Chen • Zhenhai Gao

Abstract: To improve the ride comfort and safety of a traditional adaptive cruise control (ACC) system when the preceding vehicle changes lanes, it proposes a target vehicle selection algorithm based on the prediction of the lane-changing intention for the preceding vehicle. First, the Next Generation Simulation dataset is used to train a lane-changing intention prediction algorithm based on a sliding window support vector machine, and the lane-changing intention of the preceding vehicle in the current lane is identified by lateral position offset. Second, according to the lane-changing intention and collision threat of the preceding vehicle, the target vehicle selection algorithm is studied under three different conditions: safe lane-changing, dangerous lane-changing, and lane-changing cancellation. Finally, the effectiveness of the proposed algorithm is verified in a co–simulation platform. The simulation results show that the target vehicle selection algorithm can ensure the smooth transfer of the target vehicle and effectively reduce the longitudinal acceleration fluctuation of the subject vehicle when the preceding vehicle changes lanes safely or cancels their lane change maneuver. In the case of a dangerous lane change, the target vehicle selection algorithm proposed in this paper can respond more rapidly to a dangerous lane change than the target vehicle selection method of the traditional ACC system; thus, it can effectively avoid collisions and improve the safety of the subject vehicle.



Ocean Engineering Equipment

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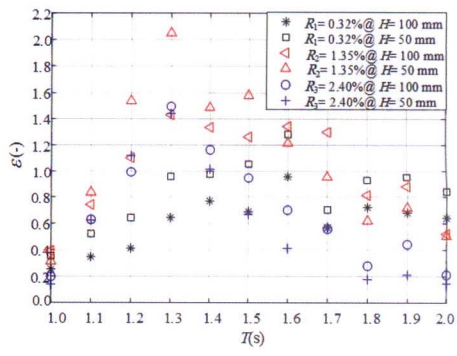
Experimental Investigation of the Small-scale Fixed Multi-chamber OWC Device

Mohammad Shalby • Ahmed Elhanafi • Paul Walker • David G. Dorrell • Ahmad Salah • Mohamed R. Gomaa

Abstract: Sea wave energy generators or converters (WECs) have the potential to become a viable technology for clean, renewable energy production. Among the WEC technologies, the oscillating water columns (OWCs) are the most common WEC devices studied. These have been studied and developed over many years. Multi-chamber oscillating water columns (MC-OWC) have the potential to have a higher energy conversion when extracting energy in mixed sea states than single-chamber devices. In the work reported in this paper, physical experiments are carried under regular wave conditions to test the wave power extraction of a fixed MC-OWC small-scale model. The Power Take-Off (PTO) of the device is simulated using orifice plates. The flow characteristics through these orifices are pre-calibrated such that the extracted power can be obtained only using the pressure measurement. Wave condition effects on the damping of the PTO of the device power extraction are addressed. The test results illustrate that the PTO system damping is critical and affects device performance.



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