cmes Springer Open

ISSN 1000-9345 · e-ISSN 2192-8258
CN 11-2737/TH · CODEN CJMEER

QK2048299

CHINESE JOURNAL OF MECHANICAL ENGINEERING®

中国机械工程学报

DOI: 10.1186/s10033-020-00476-w
Intelligent Manufacturing Systems in COVID-19 Pandemic and Beyond: Framework and Impact Assessment
Xingyu Li, Baicun Wang, Chao Liu, Theodor Freiheit, Bogdan I. Epureanu

CJME

2020 Vol. 33
August

CONTENTS

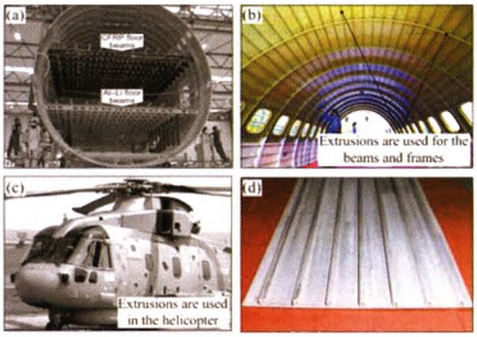
Vol. 33, August, 2020

CHINESE JOURNAL OF MECHANICAL ENGINEERING

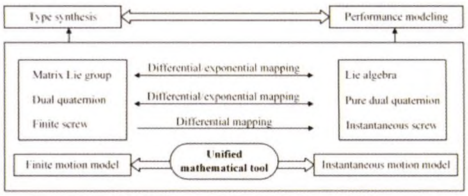
Research Highlight

Review

Abstract: Al-Li alloy is a new structural material with the advantages of lightweight and high strength. The extrusion profiles of Al-Li alloy are widely used in aerospace and other fields, which can significantly reduce the weight of the aerospace equipment and improve their carrying capacity and service performance. Particular service conditions of structural components in aeronautical and space areas put forward strict requirements on microstructure, mechanical properties, and dimensional precision of Al-Li alloy profiles. Therefore, it places higher requirements on the shape forming and microstructure controlling of the Al-Li alloy profiles. The manufacturing process of the profiles involves bille thomogenization, hot extrusion, solution and quenching treatments, artificial aging, and others. The parameters of each process as well as the die structure have important effects on the final performance of the profiles. This article summarizes the main applications and key mechanical properties of Al-Li alloy extrusion profiles.The technologies related to the manufacturing process of the extrusion profiles are summarized and analyzed. The related studies about the evolutions of the microstructure and mechanical properties during homogenization and extrusion processes are reviewed. The developments of the solid solution and quenching treatments as well as the aging strengthening technology for extruded Al-Li alloy profiles are also introduced. The scientific problems and key technologies that need to be solved in the manufacturing of Al-Li alloy extrusion profiles are presented, and the prospect for future development trends in these fields is given.



Abstract: Topology and performance are the two main topics dealt in the development of robotic mechanisms. However, it is still a challenge to connect them by integrating the modeling and design process of both parts in a unified frame. As the properties associated with topology and performance, finite motion and instantaneous motion of the robot play key roles in the procedure. On the purpose of providing a fundamental preparation for integrated modeling and design, this paper carries out a review on the existing unified mathematic frameworks for motion description and computation, involving matrix Lie group and Lie algebra, dual quaternion and pure dual quaternion, finite screw and instantaneous screw. Besides the application in robotics, the review of the work from these mathematicians concentrates on the description, composition and intersection operations of the finite and instantaneous motions, especially on the exponential-differential maps which connect the two sides. Furthermore, an in-depth discussion is worked out by investigating the algebraical relationship among these methods and their further progress in integrated robotic development. The presented review offers insightful investigation to the motion description and computation, and therefore would help designers to choose appropriate mathematical tool in the integrated design and modeling and design of mechanisms and robots.



CONTENTS

Vol. 33, August, 2020

Mechanism and Robotics

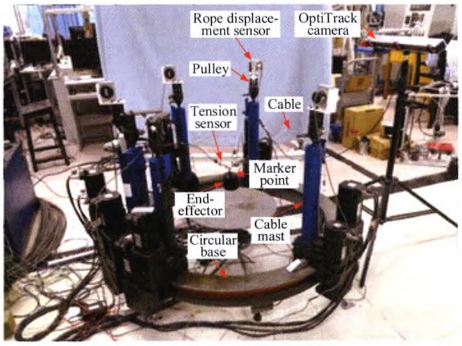
(2020)33:54

DOI: 10.1186/s10033-020-00473-z

Algebraic Method-Based Point-to-Point Trajectory Planning of an Under-Constrained Cable-Suspended Parallel Robot with Variable Angle and Height Cable Mast

Tao Zhao • Bin Zi • Sen Qian • Jiahao Zhao

Abstract: To avoid impacts and vibrations during the processes of acceleration and deceleration while possessing flexible working ways for cable-suspended parallel robots (CSPRs), point-to-point trajectory planning demands an under-constrained cable-suspended parallel robot (UCPR) with variable angle and height cable mast as described in this paper. The end-effector of the UCPR with three cables can achieve three translational degrees of freedom (DOFs). The inverse kinematic and dynamic modeling of the UCPR considering the angle and height of cable mast are completed. The motion trajectory of the end-effector comprising six segments is given. The connection points of the trajectory segments (except for point P3 in the *X* direction) are devised to have zero instantaneous velocities, which ensure that the acceleration has continuity and the planned acceleration curve achieves smooth transition. The trajectory is respectively planned using three algebraic methods, including fifth degree polynomial, cycloid trajectory, and double-S velocity curve. The results indicate that the trajectory planned by fifth degree polynomial method is much closer to the given trajectory of the end-effector. Numerical simulation and experiments are accomplished for the given trajectory based on fifth degree polynomial planning. At the points where the velocity suddenly changes, the length and tension variation curves of the planned and unplanned three cables are compared and analyzed. The OptiTrack motion capture system is adopted to track the end-effector of the UCPR during the experiment. The effectiveness and feasibility of fifth degree polynomial planning are validated.



(2020)33:56

DOI: 10.1186/s10033-020-00470-2

Compound Impedance Control of a Hydraulic Driven Parallel 3UPS/S Manipulator

Lihang Wang • Shaofei Cui • Chong Ma • Lijie Zhang

Abstract: The hydraulic parallel manipulator combines the high-power density of the hydraulic system and high rigidity of the parallel mechanism with excellent load-carrying capacity. However, the high-precision trajectory tracking control of the hydraulic parallel manipulator is challenged by the coupling dynamics of the parallel mechanism and the high nonlinearities of the hydraulic system. In this study, the trajectory control of a 3-DOF symmetric spherical parallel 3UPS/S manipulator is evaluated. Focusing on the highly coupling and nonlinear system dynamics, a compound impedance control method for a hydraulic driven parallel manipulator is proposed, which combines impedance control with the spatial motion characteristics of a parallel manipulator. The control strategy is divided into the inner and outer loops. The inner loop controls the impedance of the actuator in the joint space, and the outer loop controls the impedance of the entire platform in the task space to compensate the coupling of the actuators and improve the tracking accuracy of the moving platform. Compound impedance control does not require force or pressure sensors and is less dependent on modeling precision. The experimental results show that the compound impedance control effectively improves the tracking accuracy of the moving platform. This research proposes a compound impedance control strategy for a 3-DOF hydraulic parallel manipulator, which has high tracking precision with a simple and cheap system configuration.

CONTENTS

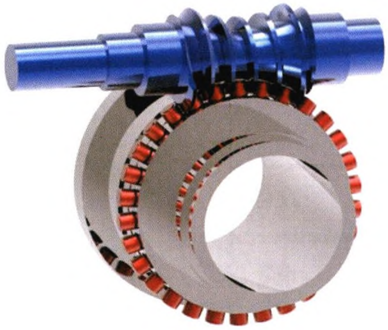
Vol. 33, August, 2020

(2020)33:59

DOI: 10.1186/s10033-020-00475-x

Temperature Field Simulation and Experimental Study of Anti-backlash Single-Roller Enveloping Hourglass Worm Gear

Shisong Wang • Shike Wang • Jie Wang • Xingqiao Deng



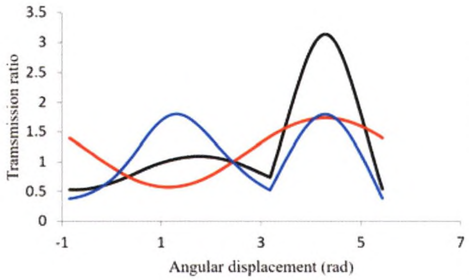
Abstract: In gear transmission, temperature rise has a non-negligible impact on the accuracy, noise and transmission efficiency. However, there is no relevant research on the temperature rise of the anti-backlash single-roller enveloping hourglass worm (ASEHW) gear. To solve this problem, based on tribology principle and Hertz contact theory, the thermal power calculation method of the ASEHW gear was proposed for the first time and thermal analysis was carried out by Ansys software. The bulk temperature of the ASEHW gear under four different rotating speed (300 r/min, 600 r/min, 900 r/min, 1 200 r/min)is calculated. The main factors causing temperature rise of the ASEHW gear are analyzed theoretically. Meanwhile, an experimental study is performed to verify the simulation results and validate the theory methods. The theory presented in this paper provides a solution for the thermal power calculation of ASEHW gear. This research provides a theoretical basis for further optimization of ASEHW gear.

(2020)33:63

DOI: 10.1186/s10033-020-00484-w

Design of Vegetable Pot Seedling Pick-up Mechanism with Planetary Gear Train

Zhipeng Tong • Gaohong Yu • Xiong Zhao • Pengfei Liu • Bingliang Ye



Abstract: It has been challenging to design seedling pick-up mechanism based on given key points and trajectories, because it involves dimensional synthesis and rod length optimization. In this paper, the dimensional synthesis of seedling pick-up mechanism with planetary gear train was studied based on the data of given key points and the trajectory of the endpoint of seedling pick-up mechanism. Given the positions and orientations requirements of the five key points, the study first conducted a dimensional synthesis of the linkage size and center of rotation. The next steps were to select a reasonable solution and optimize the data values based on the ideal seedling trajectory. The link motion was driven by the planetary gear train of the two-stage gear. Four pitch curves of noncircular gears were obtained by calculating and distributing the transmission ratio according to the data. For the pitch curve with two convex points, the tooth profile design method of incomplete noncircular gear was applied. The seedling pick-up mechanism was tested by a virtual prototype and a physical prototype designed with the obtained parameter values. The results were consistent with the theoretical design requirements, confirming that the mechanism meets the expected requirements for picking seedlings up. This paper presents a new design method of vegetable pot seedling pick-up mechanism for an automatic vegetable transplanter.

CONTENTS

Vol. 33, August, 2020

Advanced Transportation Equipment

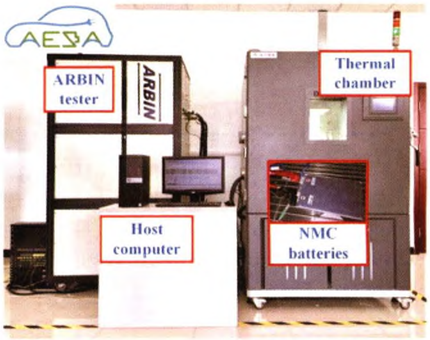
(2020)33:51

DOI: 10.1186/s10033-020-00467-x

A Comparative Study of Fractional Order Models on State of Charge Estimation for Lithium Ion Batteries

Jinpeng Tian • Rui Xiong • Weixiang Shen • Ju Wang

Abstract: State of charge (SOC) estimation for lithium ion batteries plays a critical role in battery management systems for electric vehicles. Battery fractional order models (FOMs) which come from frequency-domain modelling have provided a distinct insight into SOC estimation. In this article, we compare five state-of-the-art FOMs in terms of SOC estimation. To this end, firstly, characterisation tests on lithium ion batteries are conducted, and the experimental results are used to identify FOM parameters. Parameter identification results show that increasing the complexity of FOMs cannot always improve accuracy. The model R(RQ)W shows superior identification accuracy than the other four FOMs. Secondly, the SOC estimation based on a fractional order unscented Kalman filter is conducted to compare model accuracy and computational burden under different profiles, memory lengths, ambient temperatures, cells and voltage/current drifts. The evaluation results reveal that the SOC estimation accuracy does not necessarily positively correlate to the complexity of FOMs. Although more complex models can have better robustness against temperature variation, R(RQ), the simplest FOM, can overall provide satisfactory accuracy. Validation results on different cells demonstrate the generalisation ability of FOMs, and R(RQ) outperforms other models. Moreover, R(RQ) shows better robustness against truncation error and can maintain high accuracy even under the occurrence of current or voltage sensor drift.



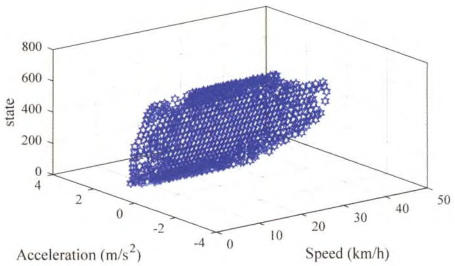
(2020)33:60

10.1186/s10033-020-00472-0

Combined Prediction for Vehicle Speed with Fixed Route

Lipeng Zhang • Wei Liu • Bingnan Qi

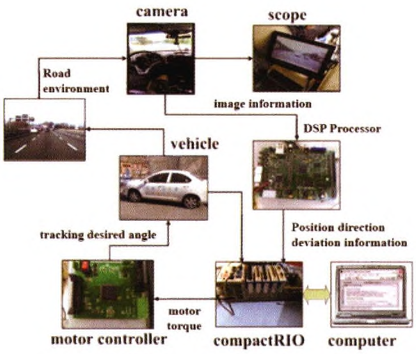
Abstract: Achieving accurate speed prediction provides the most critical support parameter for high-level energy management of plug-in hybrid electric vehicles. Nowadays, people often drive a vehicle on fixed routes in their daily travels and accurate speed predictions of these routes are possible with random prediction and machine learning, but the prediction accuracy still needs to be improved. The prediction accuracy of traditional prediction algorithms is difficult to further improve after reaching a certain accuracy; problems, such as over fitting, occur in the process of improving prediction accuracy. The combined prediction model proposed in this paper can abandon the transitional dependence on a single prediction. By combining the two prediction algorithms, the fusion of prediction performance is achieved, the limit of the single prediction performance is crossed, and the goal of improving vehicle speed prediction performance is achieved. In this paper, an extraction method suitable for fixed route vehicle speed is designed. The application of Markov and back propagation (BP) neural network in predictions is introduced. Three new combined prediction methods, all named Markov and BP Neural Network (MBNN) combined prediction algorithm, are proposed, which make full use of the advantages of Markov and BP neural network algorithms. Finally, the comparison among the prediction methods has been carried out. The results show that the three MBNN models have improved by about 19%, 28%, and 29% compared with the Markov prediction model, which has better performance in the single prediction models. Overall, the MBNN combined prediction models can improve the prediction accuracy by 25.3% on average, which provides important support for the possible optimization of plug-in hybrid electric vehicle energy consumption.



(2020)33:61
DOI: 10.1186/s10033-020-00477-9

Parallel Distributed Compensation/H∞ Control of Lane-keeping System Based on the Takagi-Sugeno Fuzzy Model

Wuwei Chen • Linfeng Zhao • Huiran Wang • Yangcheng Huang



Abstract: Current research on lane-keeping systems ignores the effect of the driver and external resistance on the accuracy of tracking the lane centerline. To reduce the lateral deviation of the vehicle, a lane-keeping control method based on the fuzzy Takagi-Sugeno(T-S) model is proposed. The method adopts a driver model based on near and far visual angles, and a driver-road-vehicle closed-loop model based on longitudinal nonlinear velocity variation, obtaining the expected assist torque with a robust H∞ controller which is designed based on parallel distributed compensation and linear matrix inequality. Considering the external influences of tire adhesion and aligning torque when the vehicle is steering, a feedforward compensation control is designed. The electric power steering system is adopted as the actuator for lane-keeping, and active steering redressing is realized by a control motor. Simulation results based on Carsim/Simulink and real vehicle test results demonstrate that the method helps to maintain the vehicle in the lane centerline and ensures driving safety.

Intelligent Manufacturing Technology

(2020)33:52
DOI: 10.1186/s10033-020-00469-9

Dynamic Stiffness Analysis and Experimental Verification of Axial Magnetic Bearing Based on Air Gap Flux Variation in Magnetically Suspended Molecular Pump

Jinji Sun • Wanting Wei • Jiqiang Tang • Chun-E Wang

Abstract: Current and displacement stiffness are important parameters of axial magnetic bearing (AMB) and are usually considered as constants for the control system. However, in actual dynamic work situations, time-varying force leads to time-varying currents and air gap with a specific frequency, which makes the stiffness of appear decrease and even worsens control performance for the whole system. In this paper, an AMB dynamic stiffness model considering the flux variation across the air gap due to frequency is established to obtain the accurate dynamic stiffness. The dynamic stiffness characteristics are analyzed by means of the dynamic equivalent magnetic circuit method. The analytical results show that the amplitude of current and displacement stiffness decreases with frequency increasing. Moreover, compared with the stiffness model without considering the variation of flux density across the air gap, the improved dynamic stiffness results are closer to the actual results. Through the dynamic stiffness measurement method of AMB, experiments of AMB in magnetically suspended molecular pump (MSMP) are carried out and the experimental results are consistent with theoretical analysis results. This paper proposes the dynamic stiffness model of axial magnetic bearing considering the variation of flux density across the air gap, which improves the accuracy of the AMB stiffness analysis.

CONTENTS

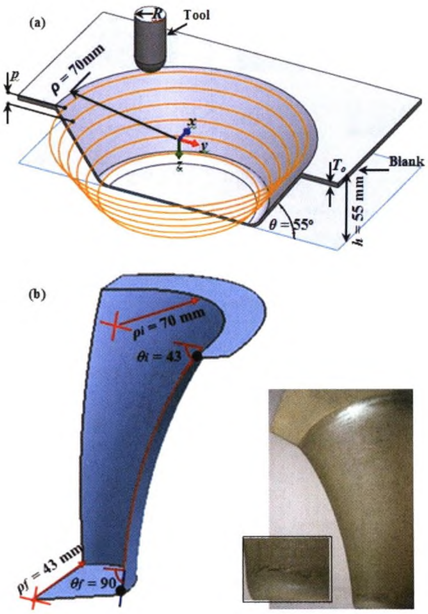
Vol. 33, August, 2020

(2020)33:55
DOI: 10.1186/s10033-020-00474-y

Formability of Materials with Small Tools in Incremental Forming

Hongyu Wei • G. Hussain • X. Shi • B. B. L. Isidore • Mohammed Alkahtani • Mustufa Haider Abidi

Abstract: Single Point Incremental Forming (SPIF) is an innovative sheet forming process with a high economic pay-off. The formability in this process can be maximized by executing forming with a tool of specific small radius, regarded as threshold critical radius. Its value has been reported as 2.2 mm for 1 mm thick sheet materials. However, with a change in the forming conditions specifically in the sheet thickness and step size, the critical radius is likely to alter due to a change in the bending condition. The main aim of the present study is to undertake this point into account and develop a relatively generic condition. The study is composed of experimental and numerical investigations. The maximum wall angle (θ_{max}) without sheet fracturing is regarded as sheet formability. A number of sheet materials are formed to fracture and the trends correlating formability with normalized radius (i.e., R/T_o where R is the tool-radius and T_o is the sheet thickness) are drawn. These trends confirm that there is a critical tool-radius (R_c) that maximizes the formability in SPIF. Furthermore, it is found that the critical radius is not fixed rather it shows dependence on the sheet thickness such that $R_c = \beta T_o$, where β varies from 2.2 to 3.3 as the thickness increases from 1 mm to 3 mm. The critical radius, however, remains insensitive to variation in step size ranging from 0.3 mm to 0.7 mm. This is also observed that the selection of tool with $R < R_c$ narrows down the formability window not only on the higher side but also on the lower side. The higher limit, as revealed by the experimental and FEA results, diminishes due to excessive shearing because of in-plane biaxial compression, and the lower limit reduces due to pillowing in the bottom of part. The new tool-radius condition proposed herein study would be helpful in maximizing the formability of materials in SPIF without performing experimental trials.

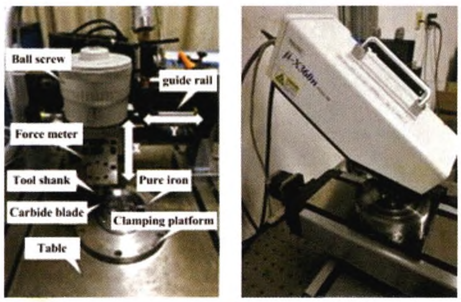


(2020)33:53
DOI: 10.1186/s10033-020-00471-1

Study on Cutting Force, Cutting Temperature and Machining Residual Stress in Precision Turning of Pure Iron with Different Grain Sizes

Yinfei Yang • Lu Jin • Jinpeng Zhu • Jinxing Kong • Liang Li

Abstract: Pure iron is one of the difficult-to-machine materials due to its large chip deformation, adhesion, work-hardening, and built-up edges formation during machining. This leads to a large workpiece deformation and challenge to meet the required technical indicators. Therefore, under varying the grain size of pure iron, the influence of cutting speed, feed, and depth of cut on the cutting force, heat generation, and machining residual stresses were explored in the turning process to improve the machinability without compromising the mechanical properties of the material. The experimental findings have depicted that the influence of grain size on cutting force in the precision turning process is not apparent. However, the cutting temperature and residual stress of machining fine-grain iron were much smaller than the coarse grain at all levels of cutting parameters.



CONTENTS

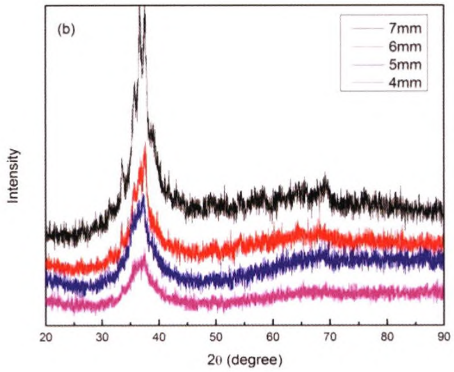
Vol. 33, August, 2020

Smart Materials

(2020)33:65
DOI: 10.1186/s10033-020-00482-y

A Novel Ni-Free Zr-Based Bulk Metallic Glass with High Glass Forming Ability, Corrosion Resistance and Thermal Stability

Yu Luo • Yidong Jiang • Pei Zhang • Xin Wang • Haibo Ke • Pengcheng Zhang

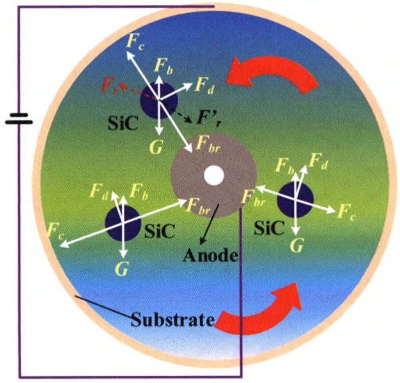


Abstract: Zr-based Bulk metallic glasses exhibit incredible corrosion resistance and glass forming ability, however, these properties need further enhancement to meet the practical use. In this study, $Zr_{63}Fe_{2.5}Cu_{23}Al_{11.5}$, a new type of Zr-basedbulk metallic glass was fabricated. Potentiodynamic polarization techniques were used to measure the corrosion resistance of this alloy. Furthermore, crystallization behavior and kinetics of $Zr_{63}Fe_{2.5}Cu_{23}Al_{11.5}$ bulk metallic glass were investigated by using differential scanning calorimetry of non-isothermal model. Kissinger and Ozawa methods were used for calculating activation energies of crystallization and the mechanism of crystallization was analyzed by Johnson-Mehl-Avrami-Kolmogorow methods. The results suggest that this specified metallic glass system possesses a relatively high thermal stability and glass forming ability. Moreover, the crystallization procedure is mainly dominated by nucleation with an increasing rate. The study demonstrates that the slight composition adjustment of Zr-Fe-Cu-Al system bulk metallic glass can make a considerable contribution to higher glass forming and thermal stability as well as corrosion resistance.

(2020)33:57
DOI: 10.1186/s10033-020-00478-8

Preparation of Nickel-Cobalt/Carborundum Carbide Composite Coatings by Supergravity Field-Enhanced Electrodeposition

Xiaoyun Hu • Ningsong Qu



Abstract: Nickel-cobalt/silicon carbide (Ni-Co/SiC) composite coatings were fabricated by supergravity field-enhanced electrodeposition. The surface morphology and the distribution of the SiC particles in the coatings were examined by scanning electron microscope and energy dispersive X-ray spectrometry. The preferred orientations of the coatings were measured by X-ray diffractometry. The wear resistance and microhardness were measured by a reciprocating tribometer and a microhardness instrument, respectively. The results revealed that the use of the supergravity field enhanced the smoothness of the as-deposited Ni-Co/SiC coatings, and the SiC nanoparticles were uniformly distributed in comparison with that for conventional electrodeposition. When the rotation speed of the cathode, which provided the supergravity field, was 800 r/min, the SiC content in the coating reached a maximum of 8.1 wt%, which was a much higher content than the 2.2 wt% value obtained under conventional electrodeposition. The highest coating microhardness of 680 HV was also observed at this rotation speed. In addition, the wear resistance of the as-prepared Ni-Co/SiC coatings exhibited improved performance relative to that prepared under normal gravity. A minimum wear weight loss of 1.4 mg together with an average friction coefficient of 0.13 were also realized at a rotation speed of 800 r/min, values which were much lower than those for normal gravity.

CHINESE JOURNAL OF MECHANICAL ENGINEERING

中国机械工程学报

(Bimonthly, Started in 1988)

Vol. 33, August 2020

Supervised by China Association for Science and Technology

Sponsored by Chinese Mechanical Engineering Society

Associated to IFToMM

Chief Editor Tianhu Song

Executive Chief Editor Shuqin Wang

Deputy Chief Editor Dan Liu

Production Editor Yingjiao Xiang

Edited by Editorial Office of Chinese Journal of Mechanical Engineering
Address: 22 Baiwanzhuang Dajie, Beijing 100037, China
Tel: +86-10-88379909
Fax: +86-10-68994557
http: //www.cjmenet.com
E-mail: cjme@cjmenet.com

Printed by Beijing BOHS Colour Printing Co., Ltd.

Subscriptions in China Post offices throughout China
Postal Code: 2-377
Subscription Price in China: ¥ 150

Coverage in Abstracting & Indexing (A&I) Services: Science Citation Index Expanded (SciSearch), Journal Citation Reports/ Science Edition, SCOPUS, DOAJ, INSPEC, Zentralblatt Math, Chemical Abstracts Service (CAS), Google Scholar, CSA, Chinese Science Citation Database, Earthquake Engineering Abstracts, EI-Compendex, OCLC, SCImago, Summon by ProQuest

Online Submission

For enquiries relating to the submission of articles (including electronic submission where available), please visit http: //www.editorialmanager.com/chme, www.cjmenet.com, or cjme.springeropen.com

ISSN 1000-9345

9 771000 934206 08>