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Effect of Trace Addition of Ceramic on Microstructure Development
and Mechanical Properties of Selective Laser Melted AISi10Mg Alloy

Yuxin Li, Dongdong Gu, Han Zhang, Lixia Xi

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Research Highlight

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SHUYU Robot: An Automatic Rapid Temperature Screening System.

Zhao Gong • Songwen Jiang • Qizhi Meng • Yanlei Ye • Peng Li • Fugui Xie • Huichan Zhao • Chunzhe Lv • Xiaojie Wang • Xinjun Liu

Review

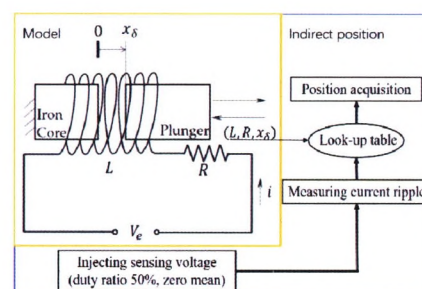
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Research and Development of Electro-hydraulic Control Valves Oriented to Industry 4.0: A Review.

Bing Xu • Jun Shen • Shihao Liu • Qi Su • Junhui Zhang

Abstract: Electro-hydraulic control valves are key hydraulic components for industrial applications and aerospace, which controls electro-hydraulic motion. With the development of automation, digital technology, and communication technology, electro-hydraulic control valves are becoming more digital, integrated, and intelligent in order to meet the requirements of Industry 4.0. This paper reviews the state of the art development for electro-hydraulic control valves and their related technologies. This review paper considers three aspects of state acquisition through sensors or indirect acquisition technologies, control strategies along with digital controllers and novel valves, and online maintenance through data interaction and fault diagnosis. The main features and development trends of electro-hydraulic control valves oriented to Industry 4.0 are discussed.



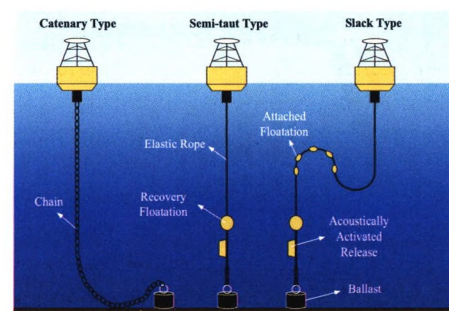
(2020)33:32

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Ocean Observation Technologies: A Review.

Mingwei Lin • Canjun Yang

Abstract: Covering about three quarters of the surface area of the earth, the ocean is a critical source of sustenance, medicine, and commerce. However, such vast expanse in both surface area and depth, presents myriad observing challenges for researchers, such as corrosion, attenuation of electromagnetic waves, and high pressure. Ocean observation technologies are progressing from the conventional single node, static and short-term modalities to multiple nodes, dynamic and long-term modalities, to increase the density of both temporal and spatial samplings. Although people's knowledge of the oceans has been still quite limited, the contributions of many nations cooperating to develop the Global Ocean Observing System (GOOS) have remarkably promoted the development of ocean observing technologies. This paper reviews the typical observing technologies deployed from the sea surface to the seafloor, and discusses the future trend of the ocean observation systems with the docking technology and sustained ocean energy.



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An Overview of Bearing Candidates for the Next Generation of Reusable Liquid Rocket Turbopumps.

Jimin Xu • Changhuan Li • Xusheng Miao • Cuiping Zhang • Xiaoyang Yuan

Abstract: There is a consensus in the aerospace field that the development of reusable liquid rockets can effectively reduce the launch expense. The pursuit of a long service life and reutilization highly depends on the bearing components. However, the rolling element bearings (REBs) used in the existing rocket turbopumps present obvious and increasing limitations due to their mechanical contacting mode. For REBs, high rotational speed and long service life are two performance indexes that mutually restrict each other. To go beyond the DN value (the product of the bearing bore and rotational speed) limit of REBs, the major space powers have conducted substantial explorations on the use of new types of bearings to replace the REB. This review discusses, first, the crucial role of bearings in rocket turbopumps and the related structural improvements of REBs. Then, with the prospect of application to the next generation of reusable liquid rocket turbopumps, the bearing candidates investigated by major space powers are summarized comprehensively. These promising alternatives to REBs include fluid-film, foil, and magnetic bearings, together with the novel superconducting compound bearings recently proposed by our team. Our more than ten years of relevant research on fluid-film and magnetic bearings are also introduced. This review is meaningful for the development of long-life and highly reliable bearings to be used in future reusable rocket turbopumps.

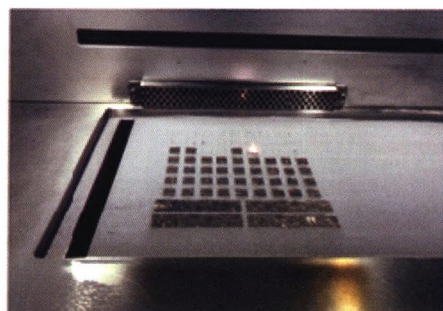
Intelligent Manufacturing Technology

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Effect of Trace Addition of Ceramic on Microstructure Development and Mechanical Properties of Selective Laser Melted AlSi10Mg Alloy.

Yuxin Li • Dongdong Gu • Han Zhang • Lixia Xi



Abstract: Selective laser melting (SLM) is an emerging additive manufacturing technology for fabricating aluminum alloys and aluminum matrix composites. Nevertheless, it remains unclear how to improve the properties of laser manufactured aluminum alloy by adding ceramic reinforcing particles. Here the effect of trace addition of TiB_2 ceramic (1% weight fraction) on microstructural and mechanical properties of SLM-produced AlSi10Mg composite parts was investigated. The densification level increased with increasing laser power and decreasing scan speed. A near fully dense composite part (99.37%) with smooth surface morphology and elevated inter-layer bonding was successfully obtained. A decrease of lattice plane distance was identified by X-ray diffraction with the laser scan speed decreased, which implied that the crystal lattices were distorted due to the dissolution of Si and TiB_2 particles. A homogeneous composite microstructure with the distribution of surface-smoothened TiB_2 particles was present, and a small amount of Si particles precipitated at the interface between reinforcing particles and matrix. In contrast to the AlSi10Mg alloy, the composites showed a stabilized microhardness distribution. A higher ultimate tensile strength of 380.0 MPa, yield strength of 250.4 MPa and elongation of 3.43% were obtained even with a trace amount of ceramic addition. The improvement of tensile properties can be attributed to multiple mechanisms including solid solution strengthening, load-bearing strengthening and dispersion strengthening. This research provides a theoretical basis for ceramic reinforced aluminum matrix composites by additive manufacturing.

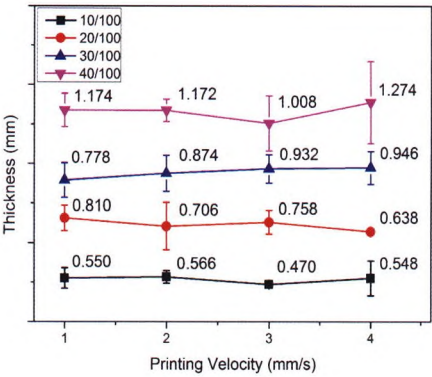
(2020)33:31

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Fiber Traction Printing: A 3D Printing Method of Continuous Fiber Reinforced Metal Matrix Composite.

Xin Wang • Xiaoyong Tian • Qin Lian • Dichen Li

Abstract: A novel metal matrix composite freeform fabrication approach, fiber traction printing (FTP), is demonstrated through controlling the wetting behavior between fibers and the matrix. This process utilizes the fiber bundle to control the cross-sectional shape of the liquid metal, shaping it from circular to rectangular which is more precise. The FTP process could resolve manufacturing difficulties in the complex structure of continuous fiber reinforced metal matrix composites. The printing of the first layer monofilament is discussed in detail, and the effects of the fibrous coating thickness on the mechanical properties and microstructures of the composite are also investigated in this paper. The composite material prepared by the FTP process has a tensile strength of 235.2 MPa, which is close to that of composites fabricated by conventional processes. The complex structures are printed to demonstrate the advantages and innovations of this approach. Moreover, the FTP method is suited to other material systems with good wettability, such as modified carbon fiber, surfactants, and aluminum alloys.



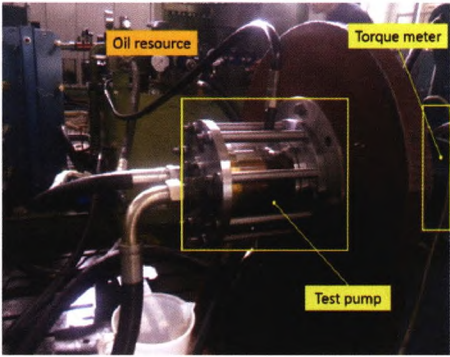
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Experimental Research on the Dynamic Lubricating Performance of Slipper/Swash Plate Interface in Axial Piston Pumps.

Junjie Zhou • Jichen Zhou • Chongbo Jing

Abstract: The interface between the slipper/swash plate is one of the most important friction pairs in axial piston pumps. The test of this interface in a real pump is very challenging. In this paper, a novel pump prototype is designed and a test rig is set up to study the dynamic lubricating performance of the slipper/swash-plate interface in axial piston machines. Such an experimental setup can simulate the operating condition of a real axial piston pump without changing the relative motion relationship of the interfaces. Considering the lubricant oil film thickness as the main measurement parameter, the attitude of the slipper under the conditions of different load pressure, rotation speed and charge pressure are studied experimentally. After the test, the wear state of the swash plate is observed. According to the friction trace on the surface of the swash plate, the prediction for the attitude of the slipper and the zone easy to wear are verified.



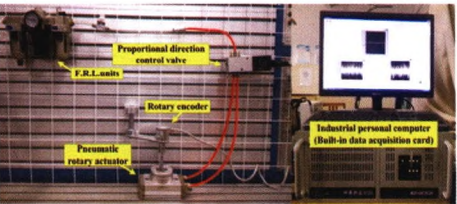
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Analysis of Power Matching on Energy Savings of a Pneumatic Rotary Actuator Servo-Control System.

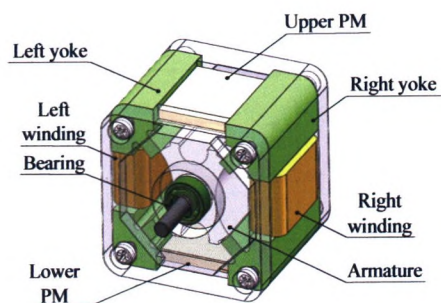
Yeming Zhang • Hongwei Yue • Ke Li • Maolin Cai

Abstract: When saving energy in a pneumatic system, the problem of energy losses is usually solved by reducing the air supply pressure. The power-matching method is applied to optimize the air-supply pressure of the pneumatic system, and the energy-saving effect is verified by experiments. First, the experimental platform of a pneumatic rotary actuator servo-control system is built, and the mechanism of the valve-controlled cylinder system is analyzed. Then, the output power characteristics and load characteristics of the system are derived, and their characteristic curves are drawn. The employed air compressor is considered as a constant-pressure source of a quantitative pump, and the power characteristic of the system is matched. The power source characteristic curve should envelope the output characteristic curve and load characteristic curve. The minimum gas supply pressure obtained by power matching represents the optimal gas supply pressure. The comparative experiments under two different gas supply pressure conditions show that the system under the optimal gas supply pressure can greatly reduce energy losses.



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Regulation Method for Torque – Angle Characteristics of Rotary Electric-Mechanical Converter Based on Hybrid Air Gap.

Bin Meng • Yongjiang Lai • Xinguo Qiu

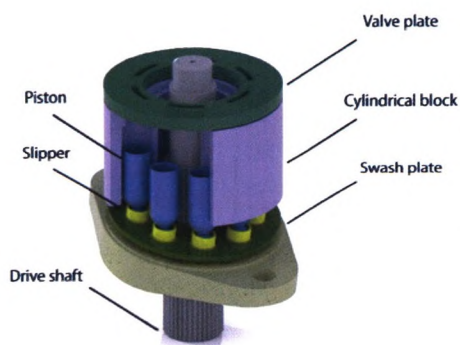
Abstract: The torque–angle characteristics of electric-mechanical converters are important determinants of the quality of electrohydraulic proportional control systems. It is far more difficult for a rotary electric–mechanical converter (REMC) to obtain flat torque–angle characteristics than traditional proportional solenoid, greatly influencing the promotion and application of rotary valves for electrohydraulic proportional control systems. A simple and feasible regulation method for the torque–angle characteristics of REMCs based on a hybrid air gap is proposed. The regulation is performed by paralleling an additional axial air gap with the original radial air gap to obtain a flat torque–angle characteristic and increase output torque. For comparison, prototypes of REMCs based on hybrid and radial air gaps were manufactured, and a special test rig was built. The torque–angle characteristics under different excitation currents and step responses were studied by magnetic circuit analysis, finite element simulation, and experimental research. The experimental results were consistent with the theoretical analysis. It was shown that REMCs based on a hybrid air gap can obtain a flat torque–angle characteristic with further optimizing of key structural parameters and also increase output torque. This regulation method provides a new approach for the design of proportional rotary electromechanical converters.

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Prediction of Leakage from an Axial Piston Pump Slipper with Circular Dimples Using Deep Neural Networks.

Özkan Özmen • Cem Sinanoğlu • Abdullah Caliskan • Hasan Badem



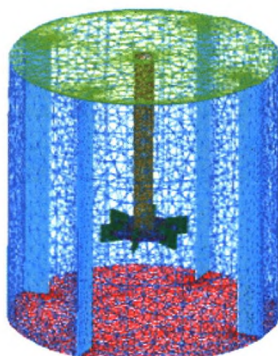
Abstract: Oil leakage between the slipper and swash plate of an axial piston pump has a significant effect on the efficiency of the pump. Therefore, it is extremely important that any leakage can be predicted. This study investigates the leakage, oil film thickness, and pocket pressure values of a slipper with circular dimples under different working conditions. The results reveal that flat slippers suffer less leakage than those with textured surfaces. Also, a deep learning-based framework is proposed for modeling the slipper behavior. This framework is a long short-term memory-based deep neural network, which has been extremely successful in predicting time series. The model is compared with four conventional machine learning methods. In addition, statistical analyses and comparisons confirm the superiority of the proposed model.

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Effect of Agitator's Types on the Hydrodynamic Flow in an Agitated Tank.

Mohammed Foukrach • Mohamed Bouzit • Houari Ameer • Youcef Kamla



Abstract: The aim of this paper is to study the effect of agitator's types on the turbulent flows in stirred tanks without and with baffles. The hydrodynamics behavior induced by four different agitator's types: a Rushton turbine (RT), a circular blade turbine (CBT), a diverging triangular blade turbine (DTBT) and converging triangular blade turbine (CTBT) are numerically predicted by solving the Navier-Stokes equations and RNG κ - ϵ turbulent model. The simulations are carried out using the Multi Reference Frame (MRF) approach. The numerical results showed good agreement with experiment. We find that the agitator CTBT gives an important profit on the power consumption per report/ratio the others and DTBT give a good reduction of the vortex size of the impeller angles.

Advanced Transportation Equipment

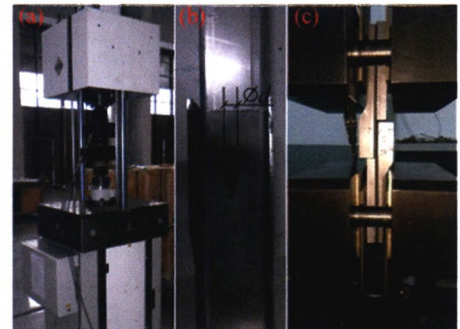
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Structural Stress – Fatigue Life Curve Improvement of Spot Welding Based on Quasi-Newton Method.

Yahang Qin • Shoune Xiao • Liantao Lu • Bing Yang • Xiangjie Li • Guangwu Yang

Abstract: Δ F-N curves are usually used to predict the fatigue life of spot welding in engineering, but they are time-consuming and laborious and not universal. For the purpose of predicting the fatigue life of spot welding accurately and efficiently, tensile–shear fatigue tests were conducted to obtain the fatigue life of spot-welded specimens with different sheet thicknesses combinations. These specimens were simulated by using the finite element method, and the structural stress was theoretically calculated. In the double logarithmic coordinate system, the structural stress–fatigue life (S–N) curve of spot welding was fitted by the least-squares method, based on the quasi-Newton method. The square of the correlation coefficient of the S–N curve was taken as the optimization objective, with the correction coefficients of force, bending moment, spot welding diameter, and sheet thickness as the variables. During the optimization process, three different ways were utilized to get three optimized spot welding S–N curves, which are suitable for different situations. The results show that the fitting effect of the S–N curve is improved, the data points are more compact, and the optimization effect is significant. These S–N curves can be used to predict the fatigue life, which provide the basis for practical engineering application.



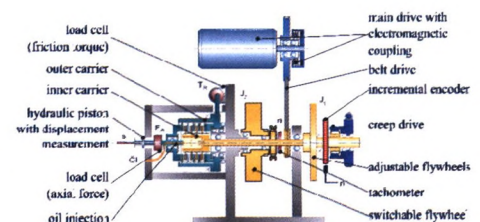
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Running-In Behavior of Wet Multi-plate Clutches: Introduction of a New Test Method for Investigation and Characterization.

Katharina Voelkel • Hermann Pflaum • Karsten Stahl

Abstract: Wet multi-plate clutches are relevant components of modern drivetrain applications, not only in terms of function but also safety and comfort. Especially at the beginning of their lifetime, distinct changes of the friction behavior may occur and make the actuation of the clutch challenging. This transcript describes the typical running-in behavior of wet multi-plate clutches and gives a general definition for running-in of clutches. Moreover, a new test method to systematically investigate the running-in behavior of clutches is introduced. This test method contains a test procedure to characterize the running-in behavior on different load levels. Furthermore, a multi-stage procedure to evaluate and characterize the running-in behavior of clutches with mathematical approaches and new characteristic values is given. The quality of the test method is demonstrated on the example of three different tribological systems from dual clutch transmissions (DCT) and automatic transmissions (AT) application using paper friction linings.



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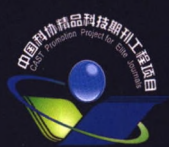
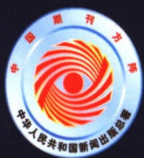
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Mass-Spring-Damping Theory Based Equivalent Mechanical Model for Cylindrical Lithium-ion Batteries under Mechanical Abuse.

Wenwei Wang • Yiding Li • Cheng Lin • Sheng Yang

Abstract: An equivalent mechanical model with the equivalent physical meaning of mass-spring-damping is proposed for cylindrical lithium-ion batteries through experiments and theory. The equivalent mechanical model of a cylindrical lithium-ion battery consists of a spring-damping parallel unit. Therefore, a spring-damping parallel unit connecting a damping unit in series is selected to construct the constitutive characteristics of the battery under mechanical abuse. Comparison results show that the equivalent mechanical model can more effectively describe the mechanical properties of the batteries than most cubic fitting models, of which the average relative error of the equivalent mechanical model under different states-of-charge is less than 6.75%. Combined with the proposed equivalent mechanical model, the failure process of the batteries was simulated and analyzed using LS-Dyna and HyperWorks. Under rigid rod tests, failure occurred at the core and bottom of the batteries; under hemispherical punch tests, failure occurred at the core and top, consistent with the experimental results. The average prediction error for the failure displacement under different abuse conditions is less than 4% in the simulations. The equivalent mechanical model requires only a few parameters and can be recognized easily. In the future, the model can be used in safety warning devices based on mechanical penetration.





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