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ISSN 1000-9[illegible]
CN 11-2737/[illegible]R



# CHINESE JOURNAL OF MECHANICAL ENGINEERING®

中国机械工程学报

DOI: 10.1186/s10033-020-00448-0

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

CJME

2020 Vol. 33
April

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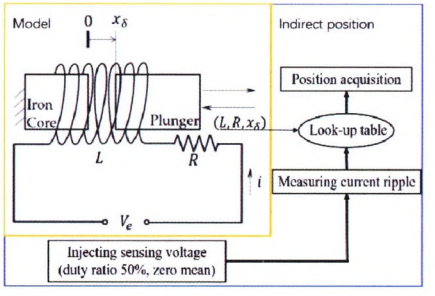
# CHINESE JOURNAL OF MECHANICAL ENGINEERING

## Research Highlight



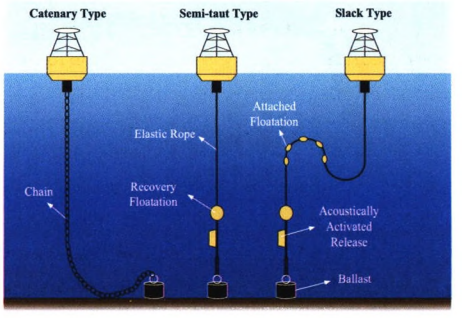
## Review






**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.






**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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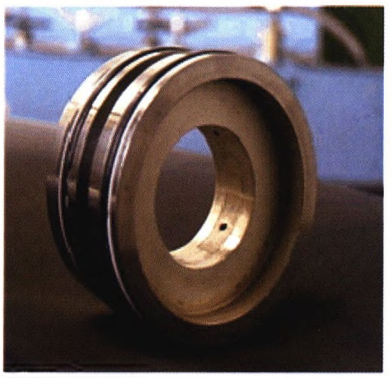


(2020)33:26

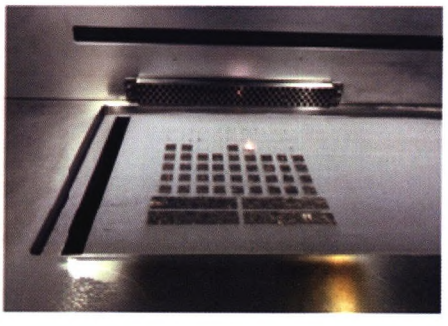
DOI: 10.1186/s10033-020-00442-6

**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



(2020)33:33

DOI: 10.1186/s10033-020-00448-0

**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.

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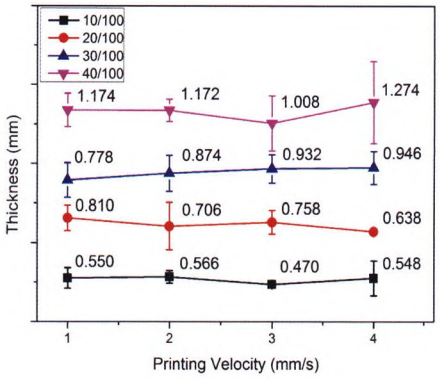




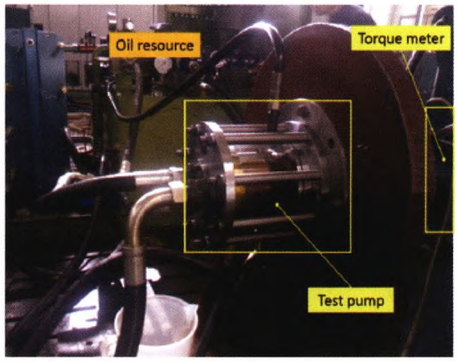




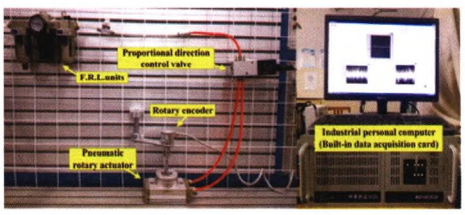

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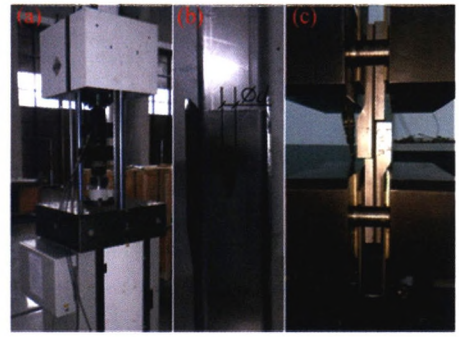
## Advanced Transportation Equipment

(2020)33:36
DOI: 10.1186/s10033-020-00453-3

**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:** △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.

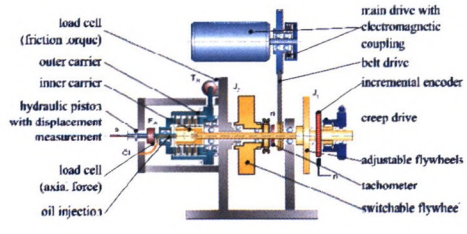



(2020)33:34
DOI: 10.1186/s10033-020-00450-6

**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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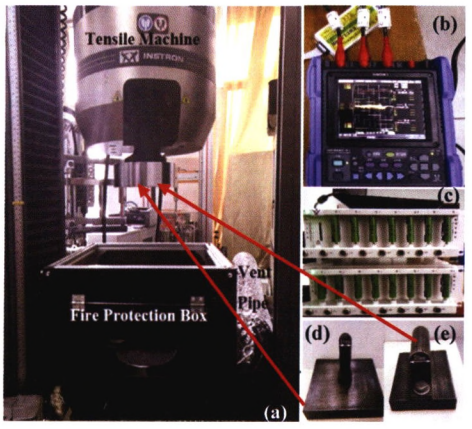
DOI: 10.1186/s10033-020-00440-8

**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.

# CHINESE JOURNAL OF MECHANICAL ENGINEERING

# 中国机械工程学报

**(Bimonthly, Started in 1988)**

**Vol. 33, April 2020**

**Supervised by** China Association for Science and Technology

**Sponsored by** Chinese Mechanical Engineering Society

**Associated to** IFToMM

**Chief Editor** Tianhu Song

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**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

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ISSN 1000-9345

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