Abstracts

Tu M. Y., Velasco J. I., Valles C., Gloria A., Lin W. Z., Li Z. M., Ruan G. L., and Liu F. **Review: Progress in the Studies on Mechanical Properties of Materials** // Problems of Strength. – 2014. – No. 2. – P. 7–11.

Materials science and engineering is one of the hot research topics in the world, among which mechanical properties of materials play a critical role in application of the new materials. Based on this, a special session Mechanical Properties of Materials was held within the 2nd Global Conference on Materials Science and Engineering, Nov. 20–22, 2013. This special issue contains a selection of twenty scientific papers, which are focused on the structure, mechanical properties, and strength of materials. In this review, the selected papers from the special session are summarized.

Wu W. P. and Yao Z. Z. **Influence of a Strain Rate and Temperature on the Crack Tip Stress and Microstructure Evolution of Monocrystalline Nickel: a Molecular Dynamics Simulation** // Problems of Strength. – 2014. – No. 2. – P. 12–21.

The effect of a strain rate and temperature on the crack tip stress and microstructure evolution ahead of a growing crack in monocrystalline nickel are studied by molecular dynamics simulations. The correlation between the microstructure evolution and stress field near the crack tip is also explored. The results indicate that the crack tip stress distribution characteristics and crack propagation dynamics are closely related to the microstructure evolution caused by the change of the strain rate and temperature. At a lower strain rate and temperature, the crack propagates by the brittle mechanism without inducing the change in atomic configuration near the crack tip. The stress concentration occurs at the crack tip of a growing crack. The crack propagation exhibits a gradual brittle-to-ductile transition with an increase in temperature and a strain rate. The peak stress is accompanied by the microstructure evolution ahead of the crack tip.

Li D. S., Zuo D. W., and Qin Q. H. **Analysis of Fracture Behavior of Thin Polycrystalline Diamond Films** // Problems of Strength. – 2014. – No. 2. – P. 22–28.

The effect of the substrate temperature and CH_4 concentrations on the fracture behavior of thin polycrystalline diamond films was systematically investigated by X-ray diffraction and scanning electron microscopy. The results show that the fracture behavior of thin polycrystalline diamond films synthesized by direct current plasma jet chemical vapor deposition is closely related to the substrate temperature and CH_4 concentrations. A high substrate temperature, due to difference in the thermal expansion coefficients of the substrate and the diamond film, causes thin polycrystalline diamond films to generate high residual stresses, which usually exceed fracture strength of thin diamond film and even that of diamond. The fracture toughness is found to drop with the increasing ratio of CH_4 concentration. In case of high CH_4 concentrations, various defects and impurities, such as cracks, microscopic holes, graphite, and amorphous carbon were observed in the films. Thus, the substrate temperature and CH_4 concentrations should be strictly controlled within an appropriate range.

Kim J. M., Park J. S., and Yun H. S. **Microstructure and Mechanical Properties of TiC Nanoparticle-Reinforced Iron-Matrix Composites** // Problems of Strength. – 2014. – No. 2. – P. 29–36.

Uniformly distributed TiC nanoparticle-reinforced iron-based composites were successfully fabricated by planetary milling in argon and subsequent hot pressing procedures. Nearly full density composite specimens could be obtained via 6-hour milling and hot pressing at 1100℃ under 50 MPa. Spherical TiC particles and fine fibrous Fe_3C phases were observed to form the iron-matrix composites and subjected to comparative analysis. Microstructural analysis results show that theaverage diameter of TiC particles and the length of Fe_3C phases tend to decrease with an increase in a TiC volume content. The compression yield strength of hot-pressed composites increased in proportion to the TiC content, resulting in 1.3 GPa for 7.5% TiC. The relationship between the microstructural characteristics and the yield strength of TiC-reinforced composites was also investigated. Based on the Orowan strengthening mechanism, a higher strength is observed for a high TiC content, mainly due to reduced distance between reinforcing TiC nanoparticles.

Feng R. C., Rui Z. Y., Zhang G. T., Yan C. F., and Yi X. B. **Improved Method of Fatigue Life**

Assessment for TiAl Alloys // Problems of Strength. – 2014. – No. 2. – P. 37–44.

For rapid fatigue life assessment of TiAl alloys, the new method was proposed based on qualitative and quantitative analyses. The qualitative analysis was employed to illustrate the microstructure effect for TiAl alloys on their fatigue life. The new formula is derived for estimation of the interaction forces of dislocations, which yields quite satisfactory results. The results of qualitative and quantitative analyses were used to predict the fatigue life improvement by the addition of trace elements producing grain refinement.

Sevim I., Sahih S., Cug H., Cevik E., Hayat F., and Karali M. **Effect of Aging Treatment on Surface Roughness, Mechanical Properties, and Fracture Behavior of 6xxx and 7xxx Aluminum Alloys** // Problems of Strength. – 2014. – No. 2. – P. 45–53.

The effect of aging treatment on the surface roughness and mechanical properties of AA6061 and AA7075 alloys was studied. Microhardness and tensile tests were used to investigae the mechanical properties. X-ray diffraction analysis was used to investigate the surface of the specimens. Furthermore, after tensile tests fractured surfaces were examined with scanning electron microscopy. An atomic force microscope was employed for analysis of the effect of aging treatment on surface roughness. Higher surface roughness with an increase in the volume fraction of the precipitate was revealed.

Chen Y. F., Peng X. D., Xu H. B., Jiang H. D., and Guan G. H. **Constitutive Equations and Processing Maps for 49MnVS3 Non-Quenched and Tempered Steel** // Problems of Strength. – 2014. – No. 2. – P. 54–65.

Flow stress variations of 49MnVS3 non-quenched and tempered steel are studied in isothermal compression tests on a Gleeble-1500D thermal simulated test machine at a deformation temperatures of 950, 1000, 1150, and 1200℃, and strain rates of 0.1, 1, 5, and 10 s^{-1}, with obtaining the strain hardening exponent n and deformation activation energy Q of the alloy. Thus, the constitutive equations and processing maps of compression flow behavior for 49MnVS3 non-quenched and tempered steel at high temperatures are established. It shows that the peak stress is shownto significantly reduced with a decrease in the strain rate and increase in deformation temperature when the alloy deforms at high temperature, and the deformation activation energy is 350.98 kJ/mol. When the true strain of 49MnVS3 non-quenched and microalloyed steel high-temperature deformation is 0.5, the optimum process parameters of the alloy are determined to be 1150–1200℃ for the deformation temperature and 2–10 s^{-1} for the strain rate, based on the criterion that the process parameters of higher power dissipation efficiency values should be chosen in the dynamic recrystallization region as the best processing technology.

Her S. C. and Wu C. L. **Annealing Effect on the Microstructure and Mechanical Properties of a Thin Titanium Nitride Film** // Problems of Strength. – 2014. – No. 2. – P. 66–72.

Titanium nitride (TiN) films were deposited by the D.C. magnetron sputtering process on a SUS 304 steel substrate. The effect of postdeposition annealing on the microstructure and mechanical properties of thin TiN films was studied in detail using atomic force microscopy, a potentiostat and nano-indentation tests. The TiN films were annealed at temperatures ranging from 100 to 300℃. Surface roughnesses of TiN films estimated by atomic force microscopy decreased from 3.83 to 2.43 nm as the annealing temperatures increased from 100 to 300°C. The corrosion rates of the films measured by a potentionstat in a 0.5-molar H_2SO_4 solution decreased from $8.57 \cdot 10^{-2}$ to $4.59 \cdot 10^{-2}$ mmPY as the annealing temperatures increased from 100 to 300°C. An increase in corrosion resistance was attributed to an increase in hardness and a modulus of the film with the annealing temperature. Atomic force microscopy images of the film revealed fine-grained morphology for TiN films annealed at higher temperature. Experimental results show that the mechanical properties of TiN films could be significantly improved by annealing. The control of the annealing process was proved to be critical for the improvement of TiN film properties.

Zhou L. L., Chu X. H., and Xu Y. J. **Evolution of Anisotropy in Granular Materials: Effect of Particle Rolling and Particle Crushing** // Problems of Strength. – 2014. – No. 2. – P. 73–80.

The effect of particle rolling and crushing on the evolutions of the two types of anisotropy, i.e., anisotropy of particle packing (microstructure) and anisotropy of force chains, is investigated

numerically using the discrete element method. To this end, the classical fabric tensor is adopted to describe the anisotropy of microstructure, while two similar orientation tensors defined by the directions of contact forces are used to characterize the anisotropy of force chains. Numerical results show that the evolutions of anisotropy follows the same tendency as the stress–strain curve, and the anisotropy of force chains is more intense than that of the microstructure. In addition, particle rolling exerts different effect on anisotropy before and after the peak stress state, and particle crushing decreases the anisotropy of granular materials.

Li W., Chen J., He J. J., Ren Y. J., Qiu W., Zhu S. Q., and Sun Y. P. **Effect of the SiC Particle Orientation Anisotropy on the Tensile Properties of a Spray-Formed SiC_p/Al-Si Composite** // Problems of Strength. – 2014. – No. 2. – P. 81–89.

The effects of the SiC particle orientation anisotropy on the tensile properties of spray-formed SiC_p/Al-Si composites was investigated and compared with that of the unreinforced matrix alloy. The addition of SiC particles increased the elastic modulus but decreased ultimate tensile strength and elongation of an Al–Si alloy under peak-aged conditions. Microstructure disolayed a preferred orientation of the reinforcement particles, which were inclined to align parallel to the extrusion axis. Meanwhile, the degree of orientation anisotropy turned to be higher with larger reinforcement sizes particle. The elastic modulus, tensile strength and elongation in the longitudinal orientation (parallel to the extrusion axis) were higher than those in the transverse orientation (perpendicular to the extrusion axis). The fracture mechanism in a composite with 4.5 μm particles was attributed to interfacial debonding between SiC and matrix in the two orientations. However, in case of aluminum reinforced wild 20 μm particles, both cracking of SiC particles in the longitudinal orientation and the interfacial debonding in the transverse orientation played an important role in fracture.

Tian H. L., Wei S. C., Chen Y. X., Tong H., Liu Y., and Xu B. S. **Microstructure and Wear Resistance of an Arc-Sprayed Fe-Based Coating after Surface Remelting Treatment** // Problems of Strength. – 2014. – No. 2. – P. 90–97.

The aim of the study was to improve the lamellar structure and wear resistance of arc-sprayed coatings. FeNiCrAl arc-sprayed coatings were remelted by the tungsten inert gas welding method. The as-sprayed and remelted specimens were subjected to comparative structural phase composition examination using optical microscopy, scanning electron microscopy and X-ray diffraction. Additionally, the effect of the remelting treatment on the wear mechanism of the arc sprayed coatings was also studied. It was found from the experiments that the tungsten inert gas surface process has the potential to form pore- and crack-free coatings. Further investigations showed that the dominant mechanism of wear for the as-sprayed coatings was oxide delamination and for the tungsten inert gas remelted coatings was cutting and ploughing.

Lee J. Y., Kim K. H., Kim S. W., and Chang M. **Strength Degradation of Glass Fiber Reinforced Polymer Bars Subjected to Reversed Cyclic Load** // Problems of Strength. – 2014. – No. 2. – P. 98–105.

Glass fiber reinforced polymer (GFRP) due to its corrosion resistance is gaining popularity in the civil engineering community, as an alternative material to steel reinforcement. GFRP reinforced bar (rebar) has a high tensile strength with moderate elastic modulus and is elastic up to failure. However, it should not be treated in the same way as steel rebar because the interfacial bond behavior of GFRP bars to concrete is expected to vary from that of conventional steel bars, since various parameters that influence bond performance are different. This paper presents the results of an experimental and analytical studies on the bond strength of glass fiber reinforced polymer bars subjected to monotonic or reversed cyclic loads. The experimental program consisted of 30 test specimens. The test results indicated that the interfacial strength of the GFRP bars was quite different to that of the steel bars. In addition, the strength degradation of GFRP bars subjected to reversed cyclic load was more severe than that of the GFRP bars subjected to a monotonic load.

Zhong Z. P., Wan S., and Jiang Z. W. **Numerical Analysis of Crack Propagation Path Using an Advanced Element Cracking Method** // Problems of Strength. – 2014. – No. 2. – P. 106–116.

The determination of the crack path is important for predicting the unexpected failures or assessing fatigue life in engineering material. To simulate the crack path under mixed mode loading using a finite element model, a new local ele-

ment cracking technique was proposed. The waiting cracking element was divided into two units along crack propagation direction based on the maximum circumference $(K_{II} = 0)$ criterion. Then, the information of element number and nodal number was also modified and singular elements were avoided by the transfixion method. With advantages of small remeshing only on a local region, this method also examined three classic problems of stationary crack growth, i.e., edge crack propagation in double cantilever beam, mode I cracking in an asphalt concrete beam, a crack in typical longitudinal connection of large natural gas carriers. The calculated stress intensity factors and the predicted crack trajectories using this method agree well with the theoretical solutions existing in literature. Optimal design of structure against failure by fast fracture is discussed.

Ni X. H., Chen C., Liu X. Q., and Zhan S. Q. **Strength Prediction Model of Particle-Reinforced Shellproof Ceramic Composite** // Problems of Strength. – 2014. – No. 2. – P. 117–124.

On the basis of the microstructure of particle-reinforced shellproof ceramic composite, and the intergranular fracture feature, a dislocation pile-up fracture model of the small-particle ceramic composite is developed, the mechanism of formation, growth and coalescence of microcracks. The complex effect of the small particle pull-out and large particle cracking is concerned, when constructing the crack extension fracture model. Thereafter, the influence of particles' volume fraction and matrix grain diameter on fracture strength is studied. The experimental data shows that the proposed strength prediction model is successful and can be generally applied.

Wang Y. X., Dong M., Li H. Y., Liu Y. Q., and Shang Q. H. **Study on Thermal Stress of Honeycomb Ceramic Regenerators with Different Parameters** // Problems of Strength. – 2014. – No. 2. – P. 125–131.

In thermal flow-reversal reactor operations, honeycomb ceramic regenerators are exposed to thermal shock load. In this study, numerical simulations of the temperature and thermal stress distributions of honeycomb ceramic regenerators are carried out using the CFX software. Temperature variations with time are calculated first for honeycomb ceramic regenerators with holes of different shapes. Then, thermal stress distributions of regenerators are analyzed with different structural and operational parameters. The analyses show that the thermal stress of honeycomb ceramic regenerator depends on the shape of holes, porosity and wall thicknesses. This study provides a theoretical basis for optimization of honeycomb ceramic regenerators.

Zhang Q., Xu M. J., and Hu N. **Study on Fatigue Life of Plow Bit under Different Planning Parameters** // Problems of Strength. – 2014. – No. 2. – P. 132–140.

In order to study the fatigue life of plow bit under different planning parameters, the process of plow bit cutting coal seam is simulated based on a solid model. The variation of the stress in the joint between the blade and carbide head is obtained by simulating the planning process with different planning parameters of the weak joint (cutting angle, plow thickness and plow spacing). The fatigue life of the plow bit is predicted using the improved rain-flow method and the Miner linear accumulated fatigue damage model. According to the experiment on plow bit life, the stress amplitude and accumulated damage in one stroke are the least at the cutting angle of 80°C, with the number of working strokes and working hours of a damaged plow bit reaching the maximum. The thicker the plow bit is, the larger is the resistance and higher is the damage. In addition, a smaller plow spacing implies a better planning ability and a smaller damage. The experimental data are consistent with the results of the theoretical analysis.

Fan X. L., Qin W. J., and Suo T. **Experimental Investigation on the Tensile Strength of Composite Laminates Containing Open and Filled Holes** // Problems of Strength. – 2014. – No. 2. – P. 141–146.

An experimental study is performed to evaluate the effects of clamping pressure, friction, and washer size on the static performance of composite laminates with open and bolt-filled holes. The static tensile strength and failure behavior of composite laminates with an open hole and a bolt-filled hole are analyzed and compared. Experimental results show that the static tensile strength of composite laminates is sensitive to pre-existing damage of both open- or filled-hole laminates. In contrast, a comparison between the experimental results of open- and filled-hole specimens proved that whether the hole is open or filled has a feeble influence on the tensile-tensile fatigue strength of studied composite laminates. In comparison, however, it is found that the inserted washer size, bolt clamping force,

and friction force strongly affect the tensile strength of open- and filled-hole composite laminates. Moreover, application of thicker washers and hi-lock bolt will significantly increase the static strength and fatigue life of composite laminates with a bolt-filled hole.

Han Z. Y., Li Y. H., and Fu H. Y. **Mechanical Properties of Thermoplastic Variable-Angle Composite Laminations for Conical Shell** // Problems of Strength. – 2014. – No. 2. – P. 147–155.

Thermoplastic composite automated fiber placement technology, as one of the extreme manufacturing technologies for large or extra large composite components with complex surface shapes, has been widely used in the field of aerospace vehicles. This paper takes 8 lamination groups with different initial placement angles generated by the conical shell variable angle placement algorithm as research objects. Variable angle placement algorithm for conical shell and finite element model establishment method for thermoplastic composite laminations of variable angle with different initial placement angles are presented. Static, modal and buckling analyses are conducted for each group. The results show that stress-strain relation, modal and buckling strength of variable-angle laminations vary regularly with the initial placement angle.

Zhu Q., Zhao J. H., Zhang C. G., Li Y., and Wang S. **Unified Solutions of Plastic Limit Internal Pressure for Metallic Elbows** // Problems of Strength. – 2014. – No. 2. – P. 156–163.

With consideration of the intermediate principal stress and different strength values in tension and compression, the plastic analysis of metallic elbows under internal pressure is conducted based on the unified strength theory. The unified solutions for elbows with constant and variable wall thickness values, and those with a local thinning are derived. Parametric studies are carried out to investigate the dependence between the unified strength theory parameter, tension-compression ratio, bending coefficient, and wall thickness. Comparing the theoretical results and the experimental data, a good agreement was observed. The results obtained show that the unified solutions are versatile in the theoretical analysis of metallic elbows and can be reduced to many existing results. The latent potentialities of metallic elbows are fully achieved due to considering the intermediate principal stress. The unified solutions have an important practical value for the optimum design and engineering application of metallic elbows.

An H. P., Rui Z. Y., Wang R. F., and Zhang Z. M. **Research on Cutting-Temperature Field and Distribution of Heat Rates among a Workpiece, Cutter, and Chip for High-Speed Cutting Based on Analytical and Numerical Methods** // Problems of Strength. – 2014. – No. 2. – P. 164–171.

High-speed cutting is widely employed in aerospace, automotive, die, and other industries. However, no comprehensive mechanism of high-speed cutting behavior was as yet comprehended completely. Models of thermal sources and fields of cutting temperature are proposed for analysis of thermal equilibrium between heat generation and energy consumption at high-speed dry cutting. Mathematic models of cutting temperature for three cutting deformation areas are developed to analyze heat generation and release behavior in high-speed machining. The ratios of heat distribution among a chip, cutter and workpiece were found for different cutting speeds using the MATLAB software.

Hu L. L. and Liu Y. **Dynamic Response of Gradient Foams** // Problems of Strength. – 2014. – No. 2. – P. 172–177.

The Voronoi-type density-gradient foams with three layers are numerically simulated, in order to study their dynamic response. The focus of the study is not only on the energy absorption and the distal stress of the gradient foam, but also the impact stress. The results obtained show that reduction of both the initial impact peak stress, and the early energy absorption of the gradient foam can be privided by reducing density of the first layer. The undesirable effect on the energy absorption can be alleviated by diminishing the thickness of the first layer. The difference between densities of the first two layers density should be limited to a certain range to avoid the peak stress appearing in the second layer. A weak distal layer can reduce the distal stress of the foam under high-velocity impact, while a high density gradient between the last two layers will result in the early increase of the distal stress under moderate-velocity impact.