哈爾濱工程大學
HARBIN ENGINEERING UNIVERSITY

Sino-Russia International Conference on Dynamic Mechanical Behaviors of Materials

November 21-22，2015 Harbin，China

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Development of Metal and Composite Polymeric Materials for Operation in Cold Climate. Computer Simulation, Experimental Studies and Materials Science Issues

Panin V.E., Panin S.V., Moiseenko D.D., Pochivalov Yu.I., Lyukshin B.A., Kornienko L.A.

Abstract

Surface layer and all interfaces in a solid under loading are to be considered as an autonomous functional subsystem where the primary plastic shears are initiated and developed. The grain boundaries nonlinear wave flows are depended on a crystal lattice curvature. Computer simulations of grain boundaries rotational wave flows for various lattices curvature were performed using modified excitable cellular automata technique. This method is offered for taking into account the grain boundary flows for the sake of computer simulation of polycrystal's behavior under deformation and fracture.

It is generally treated that the metals with BCC structure demonstrate the effect of cold embrittlement, while this effect is not the characteristic feature for materials with the FCC lattice. This question within the problem of brittle fracture of BCC refractory metals of VI group is described in detail in scientific literacy. However, there is no clear answer for it. Brittleness of BCC steels is widely studied for a long time. But the physical nature of this phenomenon is still controversial and has no unique interpretation. The structure degradation processes to take place at low-temperature in structural steels and their welded joints which give rise to their brittle fracture are of particular interest. Traditionally, this problem is associated with low deformation energy of the BCC steels crystalline structure. However, the nature of the effect is of wider origin and demand for the ways of overcoming this problem.

Within concept of physical mesomechanics a fundamentally new concept that implies a fundamental role in plasticity and fracture of solids of a local curvature of the crystalline structure has been developed. It suggests that nanoscale interstitial bifurcation vacancies [NMBV] occur in the zones of local curvature. This concept allows us not only to explain the mechanism of low-temperature degradation of structural-phase states of the BCC steels but also to improve their cold brittleness by reducing the temperature of the brittle-ductile transition in the range down to T <-80°C. Solving the problem of cold embrittlement is overdue for a wide range of structures: main oil and gas pipelines, parts of drilling and oil field equipment, autotranspoprt and others.

In order design composite polymeric materials for cold climate operation comparison on effectiveness of adding solid lubricating fillers for polymeric composites based on ultrahighmolecular weight polyethylene (UHMWPE) with graphite, molybdenum disulfide and polytetrafluoroethylene, their tribotechnical characteristics under dry friction, boundary lubrication and abrasive wearing were investigated. The optimal weight fractions of fillers in terms of improving wear resistance have been determined. The permolecular structure and topography of wear track surfaces of UHMWPE-based composites with different content of fillers have been studied. The mechanisms of increasing wear resistance are modeled and discussed.

Dynamic Fracture of Zirconium Diboride Ultra-High Temperature Ceramics under Pulse Loading

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Abstact

The ultra-high temperature ceramics (UHTC) based on zirconium diboride, titanium diboride, hafnium diboride, zirconium carbide, hafnium carbide, tantalum carbide constitute a class of promising materials for high temperature applications in the aerospace industry for hypersonic re-entry vehicles, rocket nozzle inserts, and cutting tools, wear resistant parts etc. The goal of this work is study the dynamic strength and dynamic toughness of several types UHTC, as well as the study of physical mechanisms of quasi-brittle fracture by the method of multilevel computer simulation. The complexity of prediction of mechanical properties of massive UHTC constructive elements caused with influence of residual stress, residual porosity and grain size distribution in ceramics on damage nucleation and growth. A presence of pores in ceramics leads to the reduction of fracture toughness, modulus of elasticity and strength. The computational models of a structured representative volume (RVE) of UHTC were developed using the data of structure researches of specimens manufactured by a hot pressed and a selective laser sintering. Distribution of residual thermal stress after manufacturing were estimated in assumption that temperature drop can varied within the range of 1100 K to 1600 K. Critical fracture stress under compression of mesoscale level depends not only on relative volumes of voids and inclusions, but also on its size distribution. Damage of UHTC nanocomposites can be originated under stress pulse amplitude less than the Hugoniot elastic limit of matrix. The dynamic strength under tension (the spall strength) of UHTC nanocomposites depends on relative volumes and sizes of voids and inclusions. The decreasing of the shear strength can be caused by local stresses due to a several factors such as residual thermal stresses, nano-voids near triple junctions of ceramics matrix grains, penny-shaped cracks. Results of computer simulation indicate quasi-brittle fracture of UHTC ceramics under dynamic compression and tension. The process of quasi-brittle fracture in UHTC composites is probabilistic in nature. Damage nucleation and accumulation in quasi brittle nanostructured UHTC takes place under shock compression. Fracture of nanostructured UHTC under pulse and shock-wave loadings is provided by fast processes of intercrystalline brittle fracture and relatively slow processes of quasi-brittle failure via growth and coalescence of opened microcracks.

Research on Material Point Method for Axisymmetric Explosion and Shock Problems

Zhang Fengchao，Ma Jingxin

Key words: Explosion and shock; Generalized Interpolation Material Point Method; Specular-reflection; Axial symmetry

Abstract

This paper discussed the condition of Generalized Interpolation Material Point Method (GIMP) when we used it to solve axisymmetric problems, derived basic calculation step of axisymmetric explosion and shock problems based on GIMP. Based on the theory of Material Point Method, combined with axisymmetric characteristics, introduced specular-reflection boundary condition, numerical simulations of 3-D problems which used GIMP and 2-D problems which used the reflecting boundary of GIMP were given. It shows that the result of the typical characteristic parameters in the detonation wave which used GIMP with specular-reflection boundary to solve 2-D problems matches the result of GIMP to solve 3-D problems, and improves the calculation efficiency, which can provide a useful reference in numerical simulations for axisymmetric explosion and shock problems.

Advanced Experimental Techniques of Dynamic Mechanical Behavior of Engineering Materials under Stress Wave Loading

Fengchun Jiang

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Keywords: Hopkinson bar; Advanced experimental techniques; Application; Dynamic mechanical behaviors.

Abstract

Hopkinson bar experimental methods have been widely employed to study dynamic mechanical behavior of engineering materials, some new experimental techniques were developed in recent years. This presentation introduces the progress in advanced experimental techniques of stress wave loading applied in Hopkinson bar tests, including pulse shaping, single pulse loading, two-bar loading and Hopkinson tube loading, some fundamental issues, such as loss of contact, force equilibrium state were also addressed in this talk. The detailed applications of these advanced experimental techniques in testing of MIL armor composite were finally given in this presentation。

Dynamic Strength Ceramic Nanocomposites Under Pulse Loading

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Keywords: Multi-scale simulation; high strain rates; quasi-brittle fracture; probability; nanocomposites

Abstract

The influence of mesoscopic substructures on the dynamic strength of ultra high temperature ceramic (UHTC) and hybrid nanocomposites (HC), which can be formed using additive manufacturing, was numerically investigated. Response of composites to the shock pulse impacts with amplitudes in the range of 5 GPa to 15 GPa was simulated. Multi-scale computer simulation approach was applied to research of mechanisms of failure in ceramic nanocomposites under dynamic loading. Smooth Particle Hydrodynamics (SPH) method was used for a simulation of deformation and fracture of representative volume element (RVE) of material. Model RVE takes into consideration of porous structure, phase concentrations and morphological parameters of matrix grains and reinforcing phase particle. At weak shock wave loadings the shear strength and the spall strength of ceramic and hybrid nanocomposites depends not only phase concentration and porosity, but size parameters of skeleton substructures. The influence of skeleton-frame parameter on the shear strength and the spall strength of ceramic nanocomposites with the same concentration of phases decreases with increasing amplitude of the shock pulse of microsecond duration above the double amplitude of the Hugoniot elastic limit of nanocomposites. The probability of fracture was estimated for $ZrO_2 - ZrB_2$, and $ZrB_2 - B_4C$, $ZrB_2 - SiC$ composites under pulse loadings. The critical fracture stress on meso-scale level depends not only on relative volumes of voids and inclusions, but also on the parameters of inclusions clusters. Damage of $ZrO_2 - ZrB_2$, $ZrB_2 - SiC$ and $ZrB_2 - B_4C$ nanocomposites can be formed under stress pulse amplitude of less than the Hugoniot elastic limit of matrix. These damages caused the changes of the spall strength of nanocomposites. The Hugoniot elastic limit of ceramic nanocomposites decreases with increasing volume concentration of nano-void clusters. The spall stress of ceramic nanocomposites depends on relative volumes and sizes of voids and inclusions. Self-organization process of micro-damages and occurrence of mesoscale shear band were observed in the ceramic nanocomposites under compression at high strain rates. It was shown distributions of particle velocity, pressure and equivalent stress at the mesoscale level are changed in a shock front. The distribution of these parameters in elastic precursor and behind shock wave can be described using by the 3 parameter Weibull distribution function. The

multimodal distribution of these parameters in front of volume compression wave can exist during a short time in consequence of meso-cracks growth and expansion a damaged zone near collapsing voids. Results of simulation show that damage of nano-composites near voids can be formed under stress pulse amplitude less than the Hugoniot elastic limit of matrix. Fracture of UHTC nanocomposites is realized via microcracks coalescence mechanism. Thereby fracture of $ZrO_2 - ZrB_2$, $ZrB_2 - B_4C$, $ZrB_2 - SiC$ ceramic nanocomposites under pulse loadings has a quasi-brittle behavior.

Stress Wave Propagation Behavior in Large Dimensional Hopkinson Tube Loading Fracture Test

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Keywords: Pulse shaping; Hopkinson bar; Loading tube; Fracture toughness

Abstract

The Hopkinson bar loaded two-bar (incident and transmission bar)/three-point bending fracture experiments apparatus is used to test dynamic fracture toughness of engineering materials, which is the significant improvement of Hopkinson bar technique and has lots of advantages. However, owing to limitation of loading bar diameter, the dimensions of three-point bend fracture specimen hardly satisfy the plane strain condition. Therefore, the incident and transmission tubes are proposed to take the place of solid bars. Compared to the solid bars, the distance between two supports fixed in transmission bar increases with increasing dimension of the tube, i.e. the span of three-point bending specimen increases. Such that the dynamic fracture toughness in a plane strain condition can be tested by large dimensions of three-point bending specimen. In this talk, in order to thoroughly understand the stress wave propagation behavior in a large diameter loading tube, the characteristic of the incident pulse under different impact conditions was studied experimentally and numerically. Both the experimental and simulated results indicate that the incident stress pulse characteristics depend critically on impact alignment conditions. When the striker tube impacts the end of the incident tube in an axial, normal (i.e. parallel surfaces at contact) alignment condition, the incident pulse shows an obvious dispersive effect, while under an oblique impact condition, a smooth incident pulse with a long rise time is achieved. Hence, a novel pulse shaping technique is herein proposed based on this work for achieving a tailored incident pulse used to acutely measure dynamic fracture toughness.

Processing, Microstructure and Mechanical Properties of Beta-Gamma TiAl alloy

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Keywords: TiAl alloys; investment casting; wrought processes; mechanical properties

Abstract

TiAl alloys are considered as one of the most promising novel light-weight, high-temperature structure materials applied to aerospace and civil industry due to their low density, excellent high temperature strength and creep resistance. This presentation reviews the processing, microstructure and mechanical properties of TiAl alloys based on the research in Harbin Institute of Technology.

Aimed at the improvement of mechanical properties of casting TiAl alloy, the fabrication of unique ceramic moulds for investment casting of TiAl alloys, numerical simulation and process optimization of gating system and the heat treatment of castings were carried out and identified. The results indicated that the addition of polymer into the ceramic moulds could solve the hot tearing problem in TiAl castings successfully. The novel cyclic heat treatment improved the mechanical properties of castings significantly and the tensile strength of castings was 554MPa with an elongation of 2.2% after heat treatment at room temperature.

In order to improve the hot-working character, the wrought processes of TiAl alloys were summarized. Their hot-deformation behaviors, hot processing technologies, heat treatment process, microstructure and mechanical properties were investigated systematically.The results showed that the as-forged TiAl alloy exhibited excellent room temperature tensile properties, with an ultimate tensile strength of 863MPa, yield strength of 698MPa and an elongation of 2.0%. At 700°C, the ultimate tensile strength and yield strength were 693MPa and 589MPa, respectively, with an elongation of 12.0%. The high temperature creep performance test results showed that the creep time of as-forged TiAl alloy at 700°C is 371 h, 182 h and 74 h, corresponding to stress of 200 MPa, 200 MPa and 250MPa, respectively. At last the welding properties of gamma TiAl based alloys was also presented.

Numerical Simulation of Advanced Materials and Processing Using Finite Elements Method

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Abstract

In the introduction there will be given general information about Tomsk, Tomsk's universities and scientific institutions. Then members of Tomsk's group will be introduced.
In the scientific part of the presentation there will be given the information about works which have been done in Tomsk using finite elements method. The examples of recent numerical investigations will be presented.

The Dynamic Mechanical Behavior and Equation of State of Polycarbonate

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Keywords: Polycarbonate; Dynamic mechanical properties; Constitutive model; Eequation of state

Abstract

The polycarbonate (PC) with excellent mechanical and optical properties has a wild range of applications in aerospace field. In the present study, the experimental study on dynamic mechanical behavior was conducted by using a Split Hopkinson bar. The deformation behavior of PC was obtained by the high-speed camera and 2D Digital Image Correlation (2D-DIC). Meanwhile, the plate impact experiment was carried out to measure the equation of state of PC in a single-stage gas gun, which consists of asymmetric impact technology, manganin gauges, PVDF, electromagnetic particle velocity gauges. The results indicate that the strain-rate sensitivity of PC is positive, and the tensile, compressive strength and elasticity modulus tends to increase with the loading strain rates. Then a thermal-viscoelastic constitutive model was employed to describe the dynamic tensile and compressive response of PC, and validated by contrast with the results of 2D-DIC. At last, the *D-u* Hugoniot curve of PC was gained by the least square method in high pressure loading conditions. The final results showed more closely to Carter and Marsh than other previous data.

Numerical Simulation of Multilayer Composites Failure under Dynamic Loading

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Keywords: failure; multilayer composites; numerical simulation

Abstract

The field of material microstructure design targeted for a specific set of structural and functional properties is now a recognized field of focus in materials science and engineering. A new class of structural materials called metal-intermetallic laminate (MIL) composites can have micro-, meso- and macrostructure. The superior specific properties of this class of composites makes them attractive for high-performance aerospace applications, and the fabrication method for creating MIL composites allows new embedded technologies to be incorporated into the materials, enhancing their functionality and utility.

In this work experimental and numerical investigations have been done. In the experiments the Al_3Ti – Ti samples were tested on a ballistic stand and the features of the sample failure were investigated. The processes of high-velocity interaction of a projectile with a multilayer composite target were numerically investigated in axisymmetric geometry using the finite element method. Results of computations demonstrate that destruction of the intermetallic layer is brittle as against to plastic failure of the metal layer. It was shown that the optimal composite target has higher ballistic resistance in comparison with a uniform target either Al_3Ti or Ti-6-4.

Simulation of Advanced Materials and Processing Using Movable Cellular Automaton Method (Particle Mechanics)

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Abstract

Movable cellular automata (MCA) is an efficient numerical method in particle mechanics, which assumes that any material is composed of a certain amount of elementary objects interacting among each other according to many-particle forces. MCA makes feasible simulation of solid body behavior at different scales, including viscoelastic and plastic deformation, fragmentation and further interaction of fragments as granular material. This paper presents the essentials of MCA method as well as an overview of its applications to dynamic mechanical behavior of advanced materials and processing.

One of the most interesting results obtained using MCA method are related to dynamic behavior of materials in contact loading. It includes quasi-liquid layer formation in contact patches during sliding friction of steel samples; analysis of acoustic vibration generated in sliding friction contact zone; detecting nanoscale defects in surface layer of a material using frequency analysis of the force resisting to sliding of a small counter-body on the material surface (tribospectroscopy); role of vortex-like structures in the velocity fields in elastic and non-elastic deformation of the strengthening coating and substrate under contact loading; influence of parameters of stir friction welding technology on weld structure.

A key point which distinguish the MCA form other methods is its ability to model fracture including explicit description of crack formation and propagation. This feature is demonstrated on the example of study of strength properties of zirconia ceramics on its pore structure, as well as strength of zirconia alumina concrete on the loading strain rate based on multiscale approach.

Probabilistic Approach to the Problems of the Explosive and Impact Loading of Solids

Prof. Gerasimov A.V.

Tomsk State University

The natural heterogeneity of real materials structure influencing on distribution of material physicomechanical characteristics (PMC) is one of the factors determining character of destruction. The introduction of the given factor in the equations of mechanics of a deformable solid is possible at use probabilistic laws of distribution PMC on volume of a considered design. There are problems where the fragmentation is mainly probabilistic process: for example, explosive destruction axisymmetric shells where character of blasting fragmentation are beforehand unknown. Determining influence of heterogeneity of material structure is shown as well in problems punching thin barrier, during so-called "petaling" barrier. In order that simulated process of a fragmentation reflected a real picture of behavior of the destroyed bodies, received in experiments, it is necessary to bring in casual distribution of initial deviations strength properties from rating value to PMC of a body (modeling of initial defective structures of a material).

In work the explosive fragmentation of the open and closed shells, punching a thick barrier by an shell with charge HE on a normal and under a angle, a fragmentation of a barrier and an shell after barrier piercing, punching thin barrier on a normal and under an angle, crushing of metal rings, process of high-speed impact of the laminated - spaced barrier with the steel spheres is considered.

For the description of processes of deformation and crushing of solids the model compressed ideally elastoplastic bodies is used. The basic equations describing movement of media, are base on laws of conservation of mass, impulse and energy, and are made by relations Prandtl - Reuses with the Mises flow condition. The equation of state was used in the forms of Tate and Mie – Gruneisen. As criterion of destruction at intensive shear deformations achievement by equivalent plastic deformation of the limiting value is used.

For calculation spatial elastoplastic flows and detonation products the technique realized on tetrahedral cells and basing joint application of Wilkins method for calculation of internal points of a body and Johnson method for calculation of contact interactions is used. Splitting of three-dimensional area into tetrahedrons occurs to the help of automatic construction of a grid.

The natural fragmentation thick-walled elastoplastic shells and barrier calculate with the help of introduction the probabilistic mechanism of distribution of initial defects of structure of a material for the description spall and shear cracks. The flaws in a material is modeled by variation of limiting value of the equivalent plastic deformation, which one was subjected to the normal distribution law with arithmetic mean, equal tabulated value and varied dispersion. The received results show an opportunity offered the probabilistic approach and a numerical technique to model process of natural crushing of elements of machine-building designs at intensive dynamic loadings. The created technique of the decision of problems of a fragmentation allows in the most full, from the physical point of view, to three-dimensional statement adequately to reproduce processes of crushing of solids at action of explosive and shock loadings.

Recent Progress of Metal-Intermetallic Laminate (MIL) Composites Ti/Al_3Tiat Harbin Engineering University

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Keywords: Ti-Al intermetallic; laminate composites; fiber reinforced composites; mechanical behavior; high strain rate.

Abstract

Metal-Intermetallic-Laminate (MIL) composite is a new class of light-weight high performance structural materials, which is an important research field in Institute for Advanced Metallic Materials (IAMM) at Harbin Engineering University. In this presentation, we will introduce the recent progress of MIL composites made in IAMM, including, advanced processing techniques, such as Ultrasonic Consolidation (UC) and vacuum hot processing techniques used for fabricating monolithic intermetallic alloy, Ti/Al3Ti MIL composites and various fiber reinforced MIL composites. The experimental results associated with the mechanical behavior under both quasi-static and high strain rates, ballistic performances of these composites are presented, and some new findings in interface behavior is also addressed in this talk.

Ballistic Performance of Ti/Al_3Ti Metal-Intermetallic Laminate Composite

Zhoupeijun ,Fengchun Jiang

Institute for Advanced Metallic Materials, Harbin Engineering University

Keywords: Ballistic performance; Depth of Penetration (DOP); ballistic performance index (BPI)

Abstract

Metal-intermetallic laminate composite (MIL) based on the Ti-Al system are a new class of lightweight structural materials that can be used in structural armor. The ballistic performance of Ti/Al_3Ti MIL composite was investigated in this work. The protection factors of that MIL composite Ti/Al_3Ti with the same thickness and the same mass are measured using Depth of Penetration (DOP) method to be ~0.72 and ~1.57, respectively. The ballistic performance index (BPI) of Ti/Al_3Ti determined by impact penetration testing is ~113.6 $J/(Kg/m^2)$.

The current experimental results demonstrated that the protective performance of MIL composite Ti/Al_3Ti is superior compared to the 603 armored steel. Meanwhile, the mechanical behavior of MIL composite can be enhanced by adding reinforcing components or changing the composites structure. Therefore, the MIL composite Ti/Al_3Ti is a class of promising armor material.

Nanoscale Precipitation in a Nanostructured Ferritic Alloy by Small Angle Neutron Scattering and Atom Probe Tomography

Zhongwu Zhang
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Abstract

Nanostructured ferritic alloys (NFA) exhibit excellent high temperature properties and radiation tolerance due to the formation of Y-Ti-O-enriched nanoclusters. Although it has been known that the extraordinary mechanical properties originate from these stable nanoclusters, their formation and evolution during isothermal aging treatments have not been clarified. An experimental study will be presented on the composition and kinetics of these nanoclusters using complementary state-of-the-art characterization techniques of atom probe tomography (APT) for individual nanoclusters, and small angle neutron scattering (SANS) for statistical averages. The results of this study shed light on the formation and stability of nanoclusters.

Mesoscale Modeling of Dynamic Mechanical Response of Alloys with Bimodal and Gradient Distributions of Grain Size

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Keywords: Multiscale modeling, ultrafine grained alloys, magnesium alloys, zirconium alloys, high strain rates

Abstract

Inelastic deformation and damage at the mesoscale level of E110 zirconium alloy and Ma2-1 magnesium alloys with distribution of grain size were investigated in wide loading conditions by multiscale simulation methods. The computational multiscale models of representative volume element (RVE) with the unimodal and bimodal grain size distributions were developed using the experimental data of coarse grained (CG) and ultrafine grained (UFG) alloys. The mechanical response of model RVE of alloys was simulated under compression, tension and shearing at strain rates of 0.1 to 10^5 1/s. Three types of mesoscale models, taking into account grain structure, were used to simulate the mechanical behavior of alloys. The first type models assumed a random distribution of sizes and orientations of the grains in the representative volume. Models of the second type suggested the presence of a gradient of changes in grain size in one direction or the presence. The third type modes assumed a presence of skeleton-frame structure formed by clusters of small grains. A model of damage accumulation was used to describe local failure at the mesoscopic level. The Weibull distribution was used to describe the probability of failure at a macroscopic level. The modified Smooth Particles Hydrodynamics (SPH) method was applied to simulate the mechanical response of structured alloys at the mesoscale level. Fracture of the RVE is a result of stochastic damage nucleation and growth. Grain structure may influence on the random distribution of specific plastic work over the RVE. Results of computer simulation can be used for estimation of grains size distribution influence on the dynamic strength and ductility of light HCP alloys processed by severe plastic deformation methods. It was shown the critical fracture stress of UFG alloys on mesoscale level depends on relative volumes of large grains. Microcracks nucleation at quasi-static and dynamic loading is associated with strain localization in UFG partial volumes with bimodal grain size distribution. Microcracks arise in the vicinity of coarse and ultrafine grains boundaries. It is revealed that the occurrence of bimodal grain size distributions causes the increasing of UFG alloys ductility, but decreasing of the tensile strength. Mesocracks arise in the volume filled by

fine grains and can intersect coarse grains. Fracture of fine-grained alloys with bimodal grain size distribution under dynamic loading has probabilistic character and depends on parameters of structure heterogeneity. The increasing of fine precipitations concentration not only causes the hardening but increasing of ductility of UFG alloys with bimodal grain size distribution. Localization of plastic flow in UFG HCP alloys with bimodal grain size distribution under dynamic loadings depends on the specific volume of small grains. The dynamic ductility of UFG light alloys is decreased when specific volume of fine grains is greater than 70 %. Fine precipitates in alloys not only affect the hardening but also lead to change the influence of the grains size distribution on volume concentration of shear bands.

Mechanical Properties of Shape Memory Alloy (SMA) NiTi Fiber-Reinforced Metal-Intermetallic- Laminate Composite Ti/Al_3Ti

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Key words: NiTi fiber; Metal-Intermetallic-Laminate (MIL) composite; mechanical property

Abstract

In this presentation, a novel Shape Memory Alloy (SMA) NiTi fiber-reinforced Metal-Intermetallic-Laminate (MIL) composite Ti/Al_3Ti with a volume fraction of ~3.5% NiTi was fabricated using vacuum hot pressing method. The microstructure characterization of this laminate composite was performed by Scanning Electron Microscope (SEM), Energy Dispersive Spectrometer (EDS) and X-ray diffractometer (XRD), and the mechanical properties of the NiTi fiber- reinforced laminate composite were determined by mechanical testing. The experimental results indicate that the average compressive strength and the strain to failure are ~1208MPa and ~4.4% for loading perpendicular to the layers, and ~962 MPa and ~4.8% for loading parallel to the layers, respectively.

Numerical Simulation of Dynamic Channel-Angular Pressing of Titanium Specimens

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Keywords: dynamic channel-angular pressing, severe plastic deformation, numerical simulation.

Abstract

At present, volume nanostructural and ultrafine-grained materials are considered as promising constructional and functional materials of new generation. Investigation of ultrafine-grained metals received by severe plastic deformation methods showed that they are characterized by a number of unique properties as compared to coarse-grained analogues: raised several times strength combined with good plasticity, low- and high-temperature superplasticity, cyclic and radiating resistance. Recently, a new method of severe plastic deformation was proposed – dynamic channel-angular pressing (DCAP), in which pressing of a specimen through channels is carried out by pulse loading at the expense of energy of compressed gases.

In this work, deformation of a titanium specimen during DCAP was numerically investigated in a 3D statement for the dynamic scheme of loading. Computations have been carried out by the finite element method within the framework of the elastic-plastic medium model with allowance for fracture. The effective values of initial velocity and loading pressure are determined for a titanium specimen.

A Method of Restraining GeometricDispersion Effect on SHPB by theModified Striker Bar

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Key words: split Hopkinson pressure bar (SHPB);geometricdispersion effect; modified striker bar; incident pulse

Abstract

In order to restrain the geometry dispersion effect of the stress wave propagation in conventional SHPB, the modified striker bar in Hopkinson bar loaded test system is selected. Both the experiments and the simulation using ANSYS/LS-DYNA finite element method (FEM) were performed to investigate the modified effect. After verifying the effectiveness of the used program, six modified geometries of the striker bar were simulated. The optimization results in the simulation were further compared with that of the experiment. It was found that the geometric dispersion effect of incident pulse under same loading condition can be restrained effectively by modifying the striker bar. Moreover, the experimental incident pulse has a good agreement with that of the numerical simulation curves. In the investigations of various cases, several typical incident pulses can be obtained by different modified striker bars, and these modified approaches are simple and easy to be achieved.

Dynamic Deformation Behavior and Constitutive Modeling of Ti-6Al-4V Alloy

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Key words: Ti-6Al-4V alloy, High strain rate, Constitutive model; Dynamic deformation behavior, Adiabatic shear band

ABSTRACT

In this study, the quasi-static and dynamic mechanical properties of Ti-6Al-4V alloy are studied over a wider range of strain rates from 0.001/s to 2500/s, and the Johnson-Cook (JC) constitutive model used to describe the plastic flow behavior of the Ti-6Al-4V alloy under dynamic loading is established. The optical microscope and scanning electron microscope were used to analysis the dynamic deformation behavior of Ti-6Al-4V alloy, and the failure mechanism of Ti-6Al-4V alloy under dynamic loading is analyzed in detail. Based on the experimental results, the JC model parameters are determined using both stepwise estimation and mathematical optimum. By the comparison between the model prediction and experimental results, it has been demonstrated that the parameters obtained by the mathematical optimum have a better prediction of the mechanical properties under dynamic loading. Furthermore, it is also found that when the strain rates increase from 1750/s to 2500/s, the distribution of the adiabatic shear bands (ASBs) transform to syncretic and bifurcate from self-organized characteristics.