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Numerical study on the gas-kinetic high-order schemes for solving Boltzmann model equation

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摘要: The high-order compact finite difference technique is introduced to solve the Boltzmann model equation, and the gas-kinetic high-order schemes are developed to simulate the different kinetic model equations such as the BGK model, the Shakhov model and the Ellipsoidal Statistical (ES) model in this paper. The methods are tested for the one-dimensional unsteady shock-tube problems with various Knudsen numbers, the inner flows of normal shock wave for different Mach numbers, and the two-dimensional flows past a circular cylinder and a NACA 002 airfoil to verify the reliability of the present high-order algorithm and simulate gas transport phenomena covering various flow regimes. The computed results are found in good agreement both with the theoretical prediction from continuum to rarefied gas dynamics, the related DSMC solutions, and with the experimental results. The numerical effect of the schemes with the different precision and the different types of Boltzmann collision models on the computational efficiency and computed results is investigated and analyzed. The numerical experience indicates that an approach developing and applying the gas-kinetic high-order algorithm is feasible for directly solving the Boltzmann model equation.

文献类型: Article 语种: English

作者关键词: Boltzmann model equation; velocity distribution function; high-order compact scheme; discrete velocity ordinate method; gas-kinetic high order accurate algorithm

KeyWords Plus: UNIFIED ALGORITHM; RAREFIED FLOW; SHOCK-WAVE; CONTINUUM

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Design and Modeling on Stranded Wires Helical Springs

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摘要: A stranded wires helical spring is formed of a multilayer and coaxial strand of several wires twisted together with the same direction of spiral. Compared with the conventional single wire spring, the stranded wires helical spring has the notable predominance in strength, damping and vibration reduction, which is usually used in aircraft engines, automatic weapons, etc. However, due to its complicated structure, the precise computation of its strength and rigidity need be a correct mathematical model, which then will be imported to finite element analysis software for solutions. Equations on solving geometric parameters, such as external diameters of strands and screw pitches of wires, are put forward in the paper. It also proposes a novel methodology on solving geometric parameters and establishing entity models of the stranded wires helical spring, which provides foundation of computing mechanical parameters by FEA. Then mathematical models on the centre line of the strand and the surface curve of each wire, after closing two ends in a spring, are proposed. Finally, geometric parameters are solved in a case study, and a 3D entity model of a spring with 3 layers and 16 wires is established, which has validated the accuracy of the proposed methodology and the 3D entity mathematical model. The method provides a new way to design stranded wire helical spring.

文献类型: Article 语种: English

作者关键词: stranded wires helical spring; mathematical model; finite element analysis; closing ends

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Particle image velocimetry (PIV) measurements of tip vortex wake structure of wind turbine

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摘要: Large-view flow field measurements using the particle image velocimetry (PIV) technique with high resolution CCD cameras on a rotating 1/8 scale blade model of the NREL UAE phase VI wind turbine are conducted in the engineering-oriented I broken vertical bar 3.2 m wind tunnel. The motivation is to establish the database of the initiation and development of the tip vortex to study the flow structure and mechanism of the wind turbine. The results show that the tip vortex first moves inward for a very short period and then moves outward with the wake expansion, while its vorticity decreases with time after being trailed from the trailing edge of the blade tip, and then increases continuously with the rapid rolling-up to form a strong tip vortex. The measurements also indicate that the downstream movement of the tip vortex is nearly linear in the very near wake under the test condition.

文献类型: Article 语种: English

作者关键词: wind turbine; particle image velocimetry (PIV); tip vortex; flow field

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Gas-kinetic numerical study of complex flow problems covering various flow regimes

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摘要: The Boltzmann simplified velocity distribution function equation, as adapted to various flow regimes, is described on the basis of the Boltzmann-Shakhov model from the kinetic theory of gases in this study. The discrete velocity ordinate method of gas-kinetic theory is studied and applied to simulate complex multi-scale flows. On the basis of using the uncoupling technique on molecular movements and collisions in the DSMC method, the gas-kinetic finite difference scheme is constructed by extending and applying the unsteady time-splitting method from computational fluid dynamics, which directly solves the discrete velocity distribution functions. The Gauss-type discrete velocity numerical quadrature technique for flows with different Mach numbers is developed to evaluate the macroscopic flow parameters in the physical space. As a result, the gas-kinetic numerical algorithm is established for studying the three-dimensional complex flows with high Mach numbers from rarefied transition to continuum regimes. On the basis of the parallel characteristics of the respective independent discrete velocity points in the discretized velocity space, a parallel strategy suitable for the gas-kinetic numerical method is investigated and, then, the HPF (High Performance Fortran) parallel programming software is developed for simulating gas dynamical problems covering the full spectrum of flow regimes. To illustrate the feasibility of the present gas-kinetic numerical method and simulate gas transport phenomena covering various flow regimes, the gas flows around three-dimensional spheres and spacecraft-like shapes with different Knudsen numbers and Mach numbers are investigated to validate the accuracy of the numerical methods through HPF parallel computing. The computational results determine the flow fields in high resolution and agree well with the theoretical and experimental data. This computing, in practice, has confirmed that the present gas-kinetic algorithm probably provides a promising approach for resolving hypersonic aerothermodynamic problems with the complete spectrum of flow regimes from the gas-kinetic point of view for solving the mesoscopic Boltzmann model equation. (C) 2010 Elsevier Ltd. All rights reserved.

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作者关键词: Boltzmann model equation; Velocity distribution function; Discrete velocity ordinate method; Finite difference computation; Three-dimensional complex flows; Parallel computing

KeyWords Plus: NAVIER-STOKES EQUATIONS; BOLTZMANN-EQUATION; RAREFIED FLOW; BGK SCHEME; CONTINUUM; MODELS

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Improvement of Convergence to Steady State Solutions of Euler Equations with the WENO Schemes

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摘要: The convergence to steady state solutions of the Euler equations for high order weighted essentially non-oscillatory (WENO) finite difference schemes with the Lax-Friedrichs flux splitting (Jiang and Shu, in J. Comput. Phys. 126:202-228, 1996) is investigated. Numerical evidence in Zhang and Shu (J. Sci. Comput. 31:273-305, 2007) indicates that there exist slight post-shock oscillations when we use high order WENO schemes to solve problems containing shock waves. Even though these oscillations are small in their magnitude and do not affect the "essentially non-oscillatory" property of the WENO schemes, they are indeed responsible for the numerical residue to hang at the truncation error level of the scheme instead of settling down to machine zero. Differently from the strategy adopted in Zhang and Shu (J. Sci. Comput. 31:273-305, 2007), in which a new smoothness indicator was introduced to facilitate convergence to steady states, in this paper we study the effect of the local characteristic decomposition on steady state convergence. Numerical tests indicate that the slight post-shock oscillation has a close relationship with the local characteristic decomposition process. When this process is based on an average Jacobian at the cell interface using the Roe average, as is the standard procedure for WENO schemes, such post-shock oscillation appears. If we instead use upwind-biased interpolation to approximate the physical variables including the velocity and enthalpy on the cell interface to compute the left and right eigenvectors of the Jacobian for the local characteristic decomposition, the slight post-shock oscillation can be removed or reduced significantly and the numerical residue settles down to lower values than other WENO schemes and can reach machine zero for many test cases. This new procedure is also effective for higher order WENO schemes and for WENO schemes with different smoothness indicators.

文献类型: Article 语种: English

作者关键词: WENO reconstruction; WENO interpolation; Steady state solution

KeyWordsPlus: ESSENTIALLY NONOSCILLATORY SCHEMES; HYPERBOLIC CONSERVATION-LAWS; SHOCK-CAPTURING SCHEMES; EFFICIENT IMPLEMENTATION; HIGH-ORDER; VORTEX

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Signal Analysis and Spectrum Distortion Correction for Tunable Diode Laser Absorption Spectroscopy System

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摘要: In the present paper, the signal of a tunable diode laser absorption spectroscopy (TDLAS) trace gas sensing system, which has a wavelength modulation with a wide range of modulation amplitudes, is studied based on Fourier analysis method. Theory explanation of spectrum distortion induced by laser intensity amplitude modulation is given. In order to rectify the spectrum distortion, a method of synchronous amplitude modulation suppression by a variable optical attenuator is proposed. To validate the method, an experimental setup is designed. Absorption spectrum measurement experiments on CO₂ gas were carried out. The results show that the residual laser intensity modulation amplitude of the experimental system is reduced to similar to 0.1% of its original value and the spectrum distortion improvement is 92% with the synchronous amplitude modulation suppression. The modulation amplitude of laser intensity can be effectively reduced and the spectrum distortion can be well corrected by using the given correction method and system. By using a variable optical attenuator in the TDLAS (tunable diode laser absorption spectroscopy) system, the dynamic range requirements of photoelectric detector, digital to analog converter, filters and other aspects of the TDLAS system are reduced. This spectrum distortion correction method can be used for online trace gas analyzing in process industry.

文献类型: Article 语种: Chinese

作者关键词: TDLAS; Wavelength modulation; Signal analysis; Harmonic signal; Spectrum distortion correction

KeyWords Plus: MODULATION

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Geometric conservation law and applications to high-order finite difference schemes with stationary grids

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摘要: The geometric conservation law (GCL) includes the volume conservation law (VCL) and the surface conservation law (SCL). Though the VCL is widely discussed for time-depending grids, in the cases of stationary grids the SCL also works as a very important role for high-order accurate numerical simulations. The SCL is usually not satisfied on discretized grid meshes because of discretization errors, and the violation of the SCL can lead to numerical instabilities especially when high-order schemes are applied. In order to fulfill the SCL in high-order finite difference schemes, a conservative metric method (CMM) is presented. This method is achieved by computing grid metric derivatives through a conservative form with the same scheme applied for fluxes. The CMM is proven to be a sufficient condition for the SCL, and can ensure the SCL for interior schemes as well as boundary and near boundary schemes. Though the first-level difference operators $\delta(3)$ have no effects on the SCL, no extra errors can be introduced as $\delta(3) = \delta(2)$. The generally used high-order finite difference schemes are categorized as central schemes (CS) and upwind schemes (UPW) based on the difference operator $\delta(1)$ which are used to solve the governing equations. The CMM can be applied to CS and is difficult to be satisfied by UPW. Thus, it is critical to select the difference operator $\delta(1)$ to reduce the SCL-related errors. Numerical tests based on WCNS-E-5 show that the SCL plays a very important role in ensuring free-stream conservation, suppressing numerical oscillations, and enhancing the robustness of the high-order scheme in complex grids. (C) 2010 Elsevier Inc. All rights reserved.

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作者关键词: Geometric conservation laws; Surface conservation law; High-order finite difference schemes; WCNS high-order schemes; Curvilinear coordinates

KeyWords Plus: COMPACT NONLINEAR SCHEMES; SHOCK-TURBULENCE INTERACTION; MOVING GRIDS; FLOW; RESOLUTION; IMPLEMENTATION

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Design and fabrication of stereolithography-based aeroelastic wing models

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摘要: Purpose - The purpose of this paper is to present a novel method to design and fabricate aeroelastic wing models for wind tunnel tests based on stereolithography (SL). This method can ensure the structural similarity of both external and internal structures between models and prototypes. Design/methodology/approach - An aluminum wing-box was selected as the prototype, and its natural modes were studied by FEA and scaled down to obtain the desired dynamic behavior data. According to similarity laws, the structurally similar model was designed through a sequential design procedure of dimensional scaling, stiffness optimization and mass optimization. An SL model was then fabricated, and its actual natural modes were tested and compared with the desired data of the prototype. Findings - The first two natural frequencies of the model presented strong correlation with the desired data of the prototype. Both the external and internal structures of the model matched the prototype closely. The SI-based method can significantly reduce the total mass and simplify the locating operations of balance-weights. The cost and time for the fabrication were reduced significantly. Research limitations/implications - Further investigation into the material properties of SL resins including stiffness and damping behaviors due to layered process is recommended toward higher prediction accuracy. Wind tunnel tests are needed to study the in situ performance and durability of SL models. Originality/value - Although the paper takes a wing-box as the study object, structurally similar SL models of entire wings can be obtained conveniently, benefiting from the low-stiffness material properties of SL resins and the fabrication capacity to build complex structures of SL process. This paper enhances the versatility of using SL and other rapid prototyping processes to fabricate models to predict aeroelastic characteristics of aircraft.

文献类型: Article 语种: English

作者关键词: Aerospace engineering; Wind resistance; Aerodynamics; Rapid prototypes; Elastic analysis

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Science A preliminary design and manufacturing study of hybrid lightweight high-speed wind-tunnel models

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摘要: Purpose - In view of the strength and stiffness deficiencies of current photopolymer resin models under high aerodynamic loads, the purpose of this paper is to introduce a preliminary design and manufacturing technique for hybrid lightweight high-speed wind-tunnel models with internal metal frame and surface photopolymer resin based on rapid prototyping (RP). Design/methodology/approach - Internal metal frame structure was designed to be of regular configurations that can be conveniently fabricated by conventionally mechanical manufacturing methods. Outer resin components were designed to meet configuration fidelity and surface quality, which were fabricated by RP apparatus. Combination of aerodynamics and structure was utilized to accomplish structural design, strength and stiffness calibration and vibration analysis. Structural design optimization and manufacturing method of the validated hybrid AGARD-B models were studied by analysis of manufacturing precision, surface quality processing and mechanical capability. Findings - The method with internal metal frame and outer resin has dramatically improved the overall strength and stiffness of RP parts of the hybrid AGARD-B model, and it is suitable to construct the high-speed wind-tunnel models with complex internal structure. The method could decrease the model's weight and prevent resonance occurrence among the models, wind-tunnel and support system, and shorten processing period, and also it leads to decrease in manufacturing period and cost. Research limitations/implications - Stiffness of thin components for outer resin configuration is somewhat poor under high aerodynamic loads in a high-speed wind-tunnel test, and the effect of deformation of the components on the experimental results should be taken into account. Originality/value - This method can enhance the versatility of using RP technique in the fabrication of high-speed wind-tunnel models, especially for experimental models with complex structure. Aerodynamic and structural combination design and structural optimization for hybrid models make RP techniques more practical for manufacturing high-speed wind-tunnel models.

文献类型: Article 语种: English

作者关键词: Design; Manufacturing systems; Rapid prototypes; Resins; Modelling; Wind resistance

KeyWords Plus: OPTIMIZATION; FABRICATION

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ScienceA Numerical Method for Simulation of Three Dimensional Ice Accretion on Aircrafts

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摘要: A numerical method for simulation of three dimensional ice accretion on aircraft is proposed in this paper. An Eulerian method for computation of collection efficiency on icing surface is presented at first. The external flow field of gas phase is calculated with computational fluid dynamics (CFD) method, based on which the governing equations of water phase are solved, and the corresponding collection efficiency is obtained. A three-dimensional model, considering effects of runback water, is then presented, and an iterative arithmetic for solving the model is developed. The impingement characteristics of a three elements wing are computed to evaluate the numerical method for collection efficiency calculation. Ice accretion on a MS-317 swept wing is calculated, and the consequent ice shape is compared with that of an experiment and Lewice3D. All the computational results are in good agreement with data of the experiment and reference, which indicates that the proposed method is feasible.

文献类型: Proceedings Paper 语种: English

作者关键词: ice accretion; collection efficiency; three dimensional icing model; numerical simulation

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学科类别: Physics

Extending Weighted Compact Nonlinear Schemes to Complex Grids with Characteristic-Based Interface Conditions

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摘要: There are still some challenges, such as grid quality, numerical stability, and boundary schemes, in the practical application of high-order finite difference schemes for complex configurations. This study presents some improved strategies that indicate potential engineering applications of high-order schemes. The formally fifth-order weighted compact nonlinear scheme developed by the authors is implemented on point Matched multiblock structured grids, which are generated over complex configurations to ensure the grid quality of each component block. The information transmission between neighboring blocks is carried out by new characteristic-based interface conditions that directly exchange the spatial derivatives on each side of an interface by means of a characteristic-based projection to keep the high-order accuracy and high resolution of a spatial difference scheme. The high-order scheme combined with the interface conditions is shown to be asymptotically stable. The engineering-oriented applications of the high-order strategy are demonstrated by solving several two- and three-dimensional problems with complex grid systems.

文献类型: Article 语种: English

KeyWords Plus: HIGH-ORDER-ACCURATE; BOUNDARY-CONDITIONS; DIFFERENCE-SCHEMES; EQUATIONS; FLOWS

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Hydrogen-assisted catalytic ignition characteristics of different fuels

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摘要: Hydrogen-assisted catalytic ignition characteristics of methane (CH₄), n-butane (n-C₄H₁₀) and dimethyl ether (DME) were studied experimentally in a Pt-coated monolith catalytic reactor. It is concluded that DME has the lowest catalytic ignition temperature and the least required H₂ flow, while CH₄ has the highest catalytic ignition temperature and the highest required H₂ flow among the three fuels. (C) 2010 The Combustion Institute. Published by Elsevier Inc. All rights reserved.

文献类型: Article 语种: English

KeyWords Plus: COMBUSTION; PLATINUM; MIXTURES; EXTINCTION; OXIDATION

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Web of Science 分类: Thermodynamics; Energy & Fuels; Engineering, Multidisciplinary; Engineering, Chemical

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Low Observable Moving Target Tracking Based on Modified PDA-AI

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摘要: During tracking low observable moving target in electro-optical (EO) imaging tracking system, multiple false alarms resulted from low signal-to-noise rate (SNR) would seriously debase the performance of target tracking. Probabilistic data association with amplitude information (PDA-AI) assumes that amplitude of target is not correlative among different sampling instants and larger amplitude is, greater the probability of validated measurement being target of interest would be. In EO imaging tracking system, amplitude and motion of target of interest are consistent and highly correlative. A modified PDA-AI is discussed and developed to resolve the inconsistency between PDA-AI and EO tracking system in this paper, which analyzes target motion by means of modeling amplitude and motion as well as their consistency as stationary random signal. The theory analysis with Cramer-Rao lower bound (CRLB) and experiments results show that the performance of low observable target tracking of the modified PDA-AI would be more accurate and more reliable than that of the original PDA-AI.

文献类型: Article 语种: English

作者关键词: Low observable moving target tracking; Target motion analysis; Probabilistic data association; Amplitude information; Cramer-Rao lower bound

KeyWords Plus: DATA ASSOCIATION TECHNIQUES; MOTION ANALYSIS; EO SENSORS; CLUTTER; SONAR

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Investigation on heat transfer characteristics of aircraft icing including runback water

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摘要: The heat transfer characteristics of aircraft icing process were investigated based on the theories of liquid-solid phase change and film flow. The heat transfer model which couples runback water flow with liquid-solid phase change was established and the influence of airflow parameters on the characteristics of icing growth was analyzed. The results indicate that the runback water on the icing surface will accelerate the liquid-solid phase change and the icing process. The shear stress caused by the airflow is the key factor to the runback water flow. The higher the airflow velocity, the greater the shear stress and stronger the runback water flow. Under the condition of runback water flow, the velocity and temperature of the airflow are the main causes effecting on the icing accretion. The higher the airflow velocity or the lower the temperature is, the greater the icing rate will be. The liquid water content (LWC) and the collection efficiency have weak effect on the icing rate comparatively. (C) 2010 Elsevier Ltd. All rights reserved.

文献类型: Article 语种: English

作者关键词: Aircraft; Icing; Runback water; Heat transfer

KeyWords Plus: DENDRITIC GROWTH; CONVECTION; SURFACES; MODEL; FLOW; MELT

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学科类别: Thermodynamics; Engineering; Mechanics

Aerodynamic Characteristics of Transonic and Supersonic Flow over Rectangular Cavities

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摘要: An experimental and computational investigation has been performed to investigate flow characteristics and flow-field structures for three types of rectangular cavities. The data presented herein was obtained with cavity length to depth ratio of 6, 10 and 15 at 0A degrees of attack, yawing and rolling angles of 0A degrees over free-stream Mach numbers of 0.6, 0.8, 1.2 and 1.5 at Reynolds numbers of 1.23×10^7 , 1.55×10^7 , 2.01×10^7 and 2.26×10^7 per meter. The results indicate that the shear-layer expands over the cavity leading edge and impinges on the cavity floor for closed cavity flow, whereas it bridges the open cavity. The static pressure distributions are relatively uniform with the exception of a small adverse gradient occurring ahead of the rear face inside open cavity. Cavity length to depth ratio is a key geometrical parameter to define cavity flow types and influent pressure distributions inside cavities, and its decrease induces a decrease in pressure gradient. Increase in free-stream Mach numbers results in the trend that cavity flow types transform from closed to transitional cavity flow and from transitional to open cavity flow.

文献类型: Article 语种: English

作者关键词: Cavity; Flow characteristics; Pressure distributions; Aerodynamic characteristics; Transonic and supersonic

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学科类别: Thermodynamics; Mechanics

Influences of Amorphous Phase on the Growth of Nanocrystalline Ag during Replacement Reactions

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摘要: Influences of amorphous film formation on the growth of nanocrystalline Ag during replacement reactions were investigated. Amorphous films with a thickness of 5-10 nm were observed by HRTEM on the growth tip of Ag nanopaticles. The growth of Ag nanocrytallines depends on the in situ crystallization of amorphous films. Both in situ nucleation of crystalline Ag in amorphous films and without nucleation can take place. The stability of amorphous films depends on the concentration of AgNO₃ solution. In 80 mmol.L-1 or lower AgNO₃ solution, amorphous films can exist stably, while in 400 mmol.L-1 AgNO₃ solution no amorphous films can be detected.

文献类型: Article 语种: English

作者关键词: nanocrystalline Ag; amorphous phase; crystal growth

KeyWords Plus: SHAPE-CONTROLLED SYNTHESIS; SILVER NANOSPHERES; NANOSTRUCTURES; NANOWIRES

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学科类别: Materials Science; Metallurgy & Metallurgical

Engineering Influence of H₂O and CO₂ in Air on the Combustion of Ethylene (II) -Reaction Mechanism and Kinetics Simulation

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摘要: Clean air at high temperature and velocity is used as the oxidant during fuel combustion in a hypersonic scramjet. In ground tests, however, the high-temperature air produced by combustion heating contains H₂O and CO₂ as contaminants. In this study, the influence of H₂O and CO₂ in air upon the equilibrium temperature and pressure, and the ignition delay time for ethylene combustion were investigated by a kinetics simulation method using a plug flow reactor. Different initial temperatures, pressures, and equivalence ratios were studied. We find that the presence of H₂O promotes combustion whereas CO₂ inhibits combustion. Both H₂O and CO₂ result in a decrease of the equilibrium temperature and pressure during ethylene combustion, and CO₂ has a comparatively larger influence than H₂O. The simulated result was used to interpret the experimental phenomena.

文献类型: Article 语种: Chinese

作者关键词: Kinetics simulation; Plug flow reactor; Combustion of ethylene; Contaminant

KeyWords Plus: OXYGEN-ARGON MIXTURES; SHOCK-WAVES; OXIDATION; IGNITION; FLAMES; TUBE; HYDROCARBONS; PYROLYSIS; DILUENT

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Topological structure of shock induced vortex breakdown

Zhang, SH (Zhang, Shuhai)¹; Zhang, HX (Zhang, Hanxin); Shu, CW (Shu, Chi-Wang)²

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摘要: Using a combination of critical point theory of ordinary differential equations and numerical simulation for the three-dimensional unsteady Navier-Stokes equations, We Study possible flow structures of the vortical flow, especially the unsteady vortex breakdown in the interaction between a normal shock wave and a longitudinal vortex. The topological structure contains two parts. One is the sectional streamline pattern in the cross-section perpendicular to the vortex axis. The other is the sectional streamline pattern in the symmetrical plane. In the cross-section perpendicular to the vortex axis, the sectional streamlines have spiral or centre patterns depending on a function $\lambda(x, t) = 1/\rho(\partial \rho / \partial t + \partial \rho u / \partial x)$, where x is the coordinate corresponding to the vortex axis. If $\lambda > 0$, the sectional streamlines spiral inwards in the near region of the centre. If $\lambda < 0$, the sectional streamlines spiral outwards in the same region. $\lambda = 0$, the sectional streamlines form a nonlinear centre. If λ changes its sign along the vortex axis, one or more limit cycles appear in the sectional streamlines in the cross-section perpendicular to the vortex axis. Numerical simulation For two typical cases of shock induced vortex breakdown (Erlebacher, Hussaini & Shu, J. Fluid Mech., vol. 337, 1997, p. 129) is performed. The onset and time evolution of the vortex breakdown are studied. It is found that there are more limit cycles for the sectional streamlines in the cross-section perpendicular to the vortex axis. In addition, we find that there are quadru-helix structures in the tail of the vortex breakdown.

文献类型: Article 语种: English

KeyWords Plus: FLOW; SEPARATION; STABILITY; CYLINDER; SCHEMES; WAKE

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学科类别: Mechanics; Physics

Influence of H₂O and CO₂ Contamination in Air on the Combustion Properties of Ethylene

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摘要: Clean air at high temperature and velocity acts as oxidant for fuel combustion in a hypersonic scramjet. In ground tests, however, high temperature air produced by combustion heating contains H₂O and CO₂ contaminants. In this study, the effects of contamination on the properties and wall pressure of a combustion chamber during C₂H₄ combustion was investigated. Clean air was heated via electric resistance and water vapor and carbon dioxide gas were added to simulate vitiated air. Through comparative experiments between clean air and vitiated air, effects such as the stability of the flame and the wall pressure inside the combustion chamber on the contamination during the combustion of ethylene were evaluated. Furthermore, the impacts of H₂O and CO₂ in air upon ignition delay and combustion temperature were simulated by assuming a rigid and adiabatic reactor. Results from both experiment and kinetics modeling are discussed by considering the chain reaction mechanism.

文献类型: Article 语种: Chinese

作者关键词: Kinetics simulation; Combustion of ethylene; Contaminant; Scramjet

KeyWords Plus: FLAMES; HYDROGEN

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学科类别: Chemistry

Gas-kinetic numerical schemes for one- and two-dimensional inner flows

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摘要: Several kinds of explicit and implicit finite-difference schemes directly solving the discretized velocity distribution functions are designed with precision of different orders by analyzing the inner characteristics of the gas-kinetic numerical algorithm for Boltzmann model equation. The peculiar flow phenomena and mechanism from various flow regimes are revealed in the numerical simulations of the unsteady Sod shock-tube problems and the two-dimensional channel flows with different Knudsen numbers. The numerical remainder-effects of the difference schemes are investigated and analyzed based on the computed results. The ways of improving the computational efficiency of the gas-kinetic numerical method and the computing principles of difference discretization are discussed.

文献类型: Article 语种: English

作者关键词: Boltzmann model equation; gas-kinetic numerical schemes; discrete velocity ordinate method; shock-tube problems; channel flows

KeyWords Plus: BOLTZMANN MODEL EQUATION; RAREFIED FLOW; SHOCK-WAVE; HYDRODYNAMICS; SIMULATION; CONTINUUM; SYSTEMS

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The mechanism of sound generation in the interaction between a shock wave and two counter-rotating vortices

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摘要: The interaction between a shock wave and two counter-rotating vortices is simulated systematically through solving the two-dimensional, unsteady, compressible Navier-Stokes equations using a fifth order weighted essentially nonoscillatory finite difference scheme. The main purpose of this study is to reveal the mechanism of sound generation in the interaction between a shock wave and two counter-rotating vortices. It is found that there are two regimes of sound generation in this interaction. The first regime corresponds to the shock interaction with two isolated vortices, in which the sound wave generated by the interaction between the shock wave and two counter-rotating vortices equals to the linear combination of the sound waves generated by the interactions between the same shock wave and each vortex. The second regime corresponds to the shock interaction with a coupled vortex pair, in which the sound wave comes from two processes. One is the vortex coupling, and the second is the interaction between the shock wave and the coupled vortex pair.

文献类型: Article 语种: English

作者关键词: acoustic waves; compressible flow; finite difference methods; Navier-Stokes equations; shock waves; vortices

KeyWords Plus: VORTEX INTERACTION; ACOUSTIC-WAVE; DYNAMICS

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Track Initiation for Dim Small Moving Infrared Target Based on Spatial-Temporal Hypothesis Testing

Li, ZZ (Li, Zhengzhou)¹; Qi, L (Qi, Lei)¹; Li, WY (Li, Wenyan)¹; Jin, G (Jin, Gang)^{2,3}; Wei, M (Wei, Ming)²

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摘要: Track initiation for dim small moving target particularly in a heavy clutter environment is a theoretical and technological challenge for diverse tracking systems. The different spatial-temporal characteristics presenting in sequence scans are utilized to recognize target and initialize track in this paper. In spatial domain, the small target mapped in the image is a uniform gray spot other than pixel-sized object with high congregated degree, whereas, the false alarm is independent, irrelative and lower congregated degree. In temporal domain, the target's trajectory projected on image sequence is continuous for the continuity of target motion and will appear in the neighborhood at consecutive instants with the maximum probability, on the contrary, the false alarm is disorderly, and occurs in the neighborhood at consecutive instants is impossible. Based on the spatial-temporal characteristics mentioned above, a track initiation algorithm for dim small moving target based on spatial-temporal hypothesis testing, which consists of neighborhood clustering and trajectory continuity, is derived and analyzed in detail. The theory analysis and experimental results show that this method could effectively initialize the track for dim small moving target in heavy clutter environment.

文献类型: Article 语种: English

作者关键词: Dim small moving target detection; Track initiation; Spatial-temporal processing; Hypothesis testing

KeyWords Plus: PERFORMANCE ANALYSIS; ALGORITHM 通讯作者地址: Li, ZZ (通讯作者), Commun Engn Coll Chongqing Univ, Chongqing 400044, Peoples R China

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Gas-kinetic numerical studies of three-dimensional complex flows on spacecraft re-entry

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摘要: The gas-kinetic numerical algorithm solving the Boltzmann model equation is extended and developed to study the three-dimensional hypersonic flows of spacecraft re-entry into the atmosphere in perfect gas. In this study, the simplified velocity distribution function equation for various flow regimes is presented on the basis of the kinetic Boltzmann-Shakhov model. The discrete velocity ordinate technique and numerical quadrature methods, Such as the Gauss quadrature formulas with the weight function $2/\pi(1/2) \exp(-V(2))$ and the Gauss-Legendre numerical quadrature rule, are studied to resolve the barrier in simulating complex flows from low Mach numbers to hypersonic problems. Specially, the gas-kinetic finite-difference scheme is constructed for the computation of three-dimensional flow problems, which directly captures the time evolution of the molecular velocity distribution function. The gas-kinetic boundary conditions and numerical procedures are studied and implemented by directly acting on the velocity distribution function. The HPF (high performance fortran) parallel implementation technique for the gas-kinetic numerical method is developed and applied to study the hypersonic flows around three-dimensional complex bodies. The main purpose of the current research is to provide a way to extend the gas-kinetic numerical algorithm to the flow computation of three-dimensional complex hypersonic problems with high Mach numbers. To verify the current method and simulate gas transport phenomena covering various flow regimes, the three-dimensional hypersonic flows around sphere and spacecraft shape with different Knudsen numbers and Mach numbers are studied by HPF parallel computing. Excellent results have been obtained for all examples computed. (C) 2008 Elsevier Inc. All rights reserved.

文献类型: Article 语种: English

作者关键词: Kinetic theory of gases; Velocity distribution function; Boltzmann model equation; Discrete velocity ordinate method; Finite-difference computation; Three-dimensional complex flow; Spacecraft re-entry
KeyWords Plus: NAVIER-STOKES EQUATIONS; MODEL BOLTZMANN EQUATIONS; RAREFIED FLOW; BGK SCHEME; SHOCK-WAVE; CONTINUUM; SIMULATION; ALGORITHM; ROBUST; SOLVER

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学科类别: Computer Science; Physics

A block LU-SGS implicit unsteady incompressible flow solver on hybrid dynamic grids for 2D external bio-fluid simulations

Zhang, LP (Zhang, L. P.)¹; Chang, XH (Chang, X. H.)¹; Duan, XP (Duan, X. P.)¹; Wang, ZY (Wang, Z. Y.)¹;
Zhang, HX (Zhang, H. X.)¹

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摘要: A hybrid dynamic grid generation technique for two-dimensional (2D) morphing bodies and a block lower-upper symmetric Gauss-Seidel (BLU-SGS) implicit dual-time-stepping method for unsteady incompressible flows are presented for external bio-fluid simulations. To discretize the complicated computational domain around 2D morphing configurations such as fishes and insect/bird wings, the initial grids are generated by a hybrid grid strategy firstly. Body-fitted quadrilateral (quad) grids are generated first near solid bodies. An adaptive Cartesian mesh is then generated to cover the entire computational domain. Cartesian cells which overlap the quad grids are removed from the computational domain, and a gap is produced between the quad grids and the adaptive Cartesian grid. Finally triangular grids are used to fill this gap. During the unsteady movement of morphing bodies, the dynamic grids are generated by a coupling strategy of the interpolation method based on 'Delaunay graph' and local remeshing technique. With the motion of moving/morphing bodies, the grids are deformed according to the motion of morphing body boundaries firstly with the interpolation strategy based on 'Delaunay graph' proposed by Liu and Qin. Then the quality of deformed grids is checked. If the grids become too skewed, or even intersect each other, the grids are regenerated locally. After the local remeshing, the flow solution is interpolated from the old to the new grid. Based on the hybrid dynamic grid technique, an efficient implicit finite volume solver is set up also to solve the unsteady incompressible flows for external bio-fluid dynamics. The fully implicit equation is solved using a dual-time-stepping approach, Coupling with the artificial compressibility method (ACM) for incompressible flows. In order to accelerate the convergence history in each sub-iteration, a block lower-upper symmetric Gauss-Seidel implicit method is introduced also into the solver. The hybrid dynamic grid generator is tested by a group of cases of morphing bodies, while the implicit unsteady solver is validated by typical unsteady incompressible flow case, and the results demonstrate the accuracy and efficiency of present solver. Finally, some applications for fish swimming and insect wing flapping are carried out to demonstrate the ability for 2D external bio-fluid Simulations. (C) 2008 Elsevier Ltd. All rights reserved.

文献类型: Article 语种: English

KeyWords Plus: NAVIER-STOKES EQUATIONS; IMMERSSED INTERFACE METHOD; INSECT FLIGHT; UNSTRUCTURED GRIDS; MESHES; DEFORMATION; GENERATION; SCHEME; COMPUTATIONS; ALGORITHM

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学科类别: Computer Science; Mechanics

**INVESTIGATION ON THE REYNOLDS NUMBER EFFECT ON FLOW ASYMMETRY
OVER SLENDER BODIES AT HIGH INCIDENCE**

Wang, YJ (Wang Yuanjing)¹; Fan, ZL (Fan Zhaolin)¹; Li, H (Li Hao)¹

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会议: 2nd International Symposium on Physics of Fluids 会议地点: Jiuzhaigou, PEOPLES R CHINA 会议日期: JUN 09-12, 2008

摘要: Investigation of Reynolds number effect on flow asymmetry over slender bodies at high incidence was conducted. Results show that increasing of wind velocity affects flow asymmetry by changing the intensity of the vortices; Model scale affects the distance between the main vortices, which determines the stability of the vortices and results in the discrepancy in the flow asymmetry over different scale models.

文献类型: Article; Proceedings Paper 语种: English

作者关键词: High incidence; flow asymmetry; Reynolds number effect

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学科类别: Physics

**ANALYSIS OF THE EFFECTS OF MASS-INJECTION AT THE LEADING EDGE ON
CAVITY FLOW CHARACTERISTICS**

Wu, JF (Wu, Ji Fei)¹; Fan, ZL (Fan, Zhao Lin)¹; Luo, XF (Luo, Xin Fu)¹

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会议: 2nd International Symposium on Physics of Fluids 会议地点: Jiuzhaigou, PEOPLES R CHINA 会议日期: JUN 09-12, 2008

摘要: An experimental investigation was conducted in a high speed wind tunnel to explore the effects of mass-injection on cavity flow characteristics. Detailed static-pressure and fluctuating pressure measurements were obtained at the cavity floor to enable the effects of the mass-injection at the leading edge to be determined. Results indicate that varying mass-injection hole number and the flux rate of mass-injection has no significant effect on cavity flow characteristics. However, mass-injection can reduce the cavity static pressure gradient when the cavity flow type is transitional-cavity flow. The study also indicates that Mach number can influence the effect of mass-injection on cavity fluctuating pressure distributions, and at supersonic speeds, mass-injection can suppress the cavity tones effectively

文献类型: Article; Proceedings Paper 语种: English

作者关键词: Cavity; sound pressure level (SPL); cavity tone

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Gas-kinetic description of shock wave structures by solving Boltzmann model equation

Li, ZH (Li, Zhi-Hui)^{1,2}; Zhang, HX (Zhang, Han-Xin)¹

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摘要: On the basis of the mesoscopic theory of Boltzmann-type velocity distribution function, the modified Boltzmann model equation describing the one-dimensional gas flows from various flow regimes is presented by incorporating the molecular interaction models relating to the viscosity and diffusion cross-sections, density, temperature and the dependent exponent of viscosity into the molecular collision frequency. The gas-kinetic numerical method for directly solving the molecular velocity distribution function is studied by introducing the reduced distribution functions and the discrete velocity ordinate method, in which the unsteady time-splitting method and the NND finite difference scheme are applied. To study the inner flows of non-equilibrium shock wave structures, the one-dimensional unsteady shock-tube problems with various Knudsen numbers and the steady shock wave problems at different Mach numbers are numerically simulated. The computed results are found to give good agreement with the theoretical, DSMC and experimental results. The computing practice has confirmed the good precision and reliability of the gas-kinetic numerical algorithm in solving the highly nonequilibrium shock wave disturbances from various flow regimes.

文献类型: Article 语种: English

作者关键词: shock waves; kinetic theory; Boltzmann model equation; velocity distribution function; discrete velocity ordinate technique; numerical methods

KeyWords Plus: THEORETIC DESCRIPTION; BURNETT DESCRIPTION; STATISTICAL MODELS; PRANDTL NUMBER; RAREFIED FLOW; CONTINUUM; SCHEMES; PLANE

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学科类别: Mechanics; Physics

Robust airfoil optimization with multi-objective estimation of distribution algorithm

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摘要: A transonic airfoil designed by means of classical point-optimization may result in its dramatically inferior performance under off-design conditions. To overcome this shortcoming, robust design is proposed to find out the optimal profile of an airfoil to maintain its performance in an uncertain environment. The robust airfoil optimization is aimed to minimize mean values and variances of drag coefficients while satisfying the lift and thickness constraints over a range of Mach numbers. A multi-objective estimation of distribution algorithm is applied to the robust airfoil optimization on the base of the RAE2822 benchmark airfoil. The shape of the airfoil is obtained through superposing ten Hick-Henne shape functions upon the benchmark airfoil. A set of design points is selected according to a uniform design table for aerodynamic evaluation. A Kriging model of drag coefficient is constructed with those points to reduce computing costs. Over the Mach range from 0.7 to 0.8, the airfoil generated by the robust optimization has a configuration characterized by super-critical airfoil with low drag coefficients. The small fluctuation in its drag coefficients means that the performance of the robust airfoil is insensitive to variation of Mach number.

文献类型: Article 语种: English

作者关键词: airfoil robust design; multi-objective estimation of distribution algorithm; uncertain environment; drag; fluctuation

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学科类别: Engineering

Development of nonlinear weighted compact schemes with increasingly higher order accuracy

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摘要: In this paper, we design a class of high order accurate nonlinear weighted compact schemes that are higher order extensions of the nonlinear weighted compact schemes proposed by Deng and Zhang [X. Deng, H. Zhang, Developing high-order weighted compact nonlinear schemes, J. Comput. Phys. 165 (2000) 22-44] and the weighted essentially non-oscillatory schemes of Jiang and Shu [G.-S. Jiang, C.-W. Shu, Efficient implementation of weighted ENO schemes, J. Comput. Phys. 126 (1996) 202-228] and Balsara and Shu [D.S. Balsara, C.-W. Shu, Monotonicity preserving weighted essentially non-oscillatory schemes with increasingly high order of accuracy, J. Comput. Phys. 160 (2000) 405-452]. These nonlinear weighted compact schemes are proposed based on the cell-centered compact scheme of Lele [S.K. Lele, Compact finite difference schemes with spectral-like resolution, J. Comput. Phys. 103 (1992) 16-42]. Instead of performing the nonlinear interpolation on the conservative variables as in Deng and Zhang (2000), we propose to directly interpolate the flux on its stencil. Using the Lax-Friedrichs flux splitting and characteristic-wise projection, the resulted interpolation formulae are similar to those of the regular WENO schemes. Hence, the detailed analysis and even many pieces of the code can be directly copied from those of the regular WENO schemes. Through systematic test and comparison with the regular WENO schemes, we observe that the nonlinear weighted compact schemes have the same ability to capture strong discontinuities, while the resolution of short waves is improved and numerical dissipation is reduced. (c) 2008 Elsevier Inc. All rights reserved.

文献类型: Article 语种: English

作者关键词: compact scheme; weighted interpolation; WENO scheme; smoothness indicator

KeyWords Plus: FINITE-DIFFERENCE SCHEMES; ESSENTIALLY NONOSCILLATORY SCHEMES; SHOCK-TURBULENCE INTERACTION; EFFICIENT IMPLEMENTATION; VORTEX INTERACTIONS; CAPTURING SCHEMES; SOUND GENERATION; WENO SCHEMES; ENO SCHEMES; RESOLUTION

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学科类别: Computer Science; Physics

Design and fabrication of a hybrid surface-pressure airfoil model based on rapid prototyping

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摘要: Purpose - The purpose of this paper is to develop and present a hybrid design and fabrication method based on rapid prototyping (RP) and electrochemical deposition (ED) techniques to fabricate a pressure wind-tunnel model with complex internal structure and sufficient mechanical strength.

Design/methodology/approach - After offsetting inward by applied coating thickness, the airfoil model was modified with three pairs of deflecting control surfaces and 24 surface pressure taps and internal passages. The stereolithography (SL) prototype components were fabricated on SL apparatus and roughened by chemical treatments. And then metal-coated SL components of the airfoil model were created by ED technique. After assembling, a hybrid pressure airfoil model was obtained. Findings - Electrodeposited nickel coating has dramatically improved the overall strength and stiffness of SL parts and the hybrid fabrication method is suitable to construct the wind-tunnel model with complex internal structure and sufficient mechanical strength,

Research limitations/implications - interface adhesion of SL-coating is poor even if chemical roughening is applied and the further research is needed. Originality/value - This method enhances the versatility of using RP in the fabrication of functional models, especially when complex structure with sufficient mechanical properties is considered. Although this paper took an airfoil wind-tunnel model as an example, it is capable of fabricating other functional components with other rapid prototyping techniques such as FDM, SLS and LOM.

文献类型: Article 语种: English

作者关键词: rapid prototypes; electrodeposition

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Web of Science 分类: Engineering, Mechanical; Materials Science, Multidisciplinary

学科类别: Engineering; Materials

Science Rapid fabrication of metal-coated composite stereolithography parts

Zhou, Z (Zhou, Z.); Li, D (Li, D.); Zeng, J (Zeng, J.); Zhang, Z (Zhang, Z.)

来源出版物: PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS PART B-JOURNAL OF ENGINEERING MANUFACTURE 卷: 221 期: 9 页: 1431-1440 DOI: 10.1243/09544054JEM827 出版年: SEP 2007

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摘要: In this paper, the rapid fabrication method based on stereolithography (SL) and electrochemical deposition is described in detail and mechanical test results of composite nickel-coated SL parts are presented. Coatings of electrodeposited nickel on SL prototypes result in increases in Young's modulus, UTS, flexural modulus, and strength. Electrodeposited nickel coating has dramatically improved the overall strength and stiffness of SL parts. The adhesive strength of the roughened SL resin-nickel interface is higher than the original. In particular, the influence of the surface roughness on adhesive strength between SL and metal is investigated. Moreover, this paper has presented an application of a structural electrodeposited nickel coating over SL parts to make a functional airfoil model with a complex internal structure and sufficient mechanical strength and stiffness.

文献类型: Article 语种: English

作者关键词: stereolithography; electrochemical deposit; composite; rapid prototyping and manufacturing (RP&M)

KeyWords Plus: ADHESION; DESIGN

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学科类别: Engineering

A characteristic-based shock-capturing scheme for hyperbolic problems

Tu, GH (Tu Guo-Hua)¹; Yuan, XJ (Yuan Xiang-Jiang)

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摘要: In order to suppress numerical oscillations of linear compact schemes around discontinuities, a characteristic-based flux splitting limited method is introduced instead of ENO/WENO or other shock-capturing algorithms. This method begins with upwind schemes and flux vector splittings. The upwind schemes are projected along characteristic directions in a different way, and their amplitudes are carefully controlled by a special limiter in order to meet entropy condition and to prevent non-physical oscillations. A fifth-order linear compact upwind scheme is modified by this method for solving problems involving discontinuities. The properties of the numerical algorithm are checked on some benchmark problems in one, two and three space dimensions. Numerical results show that it is high-order accurate with high resolution and oscillation-free. (c) 2007 Elsevier Inc. All rights reserved.

文献类型: Article 语种: English

作者关键词: high accuracy; high-order scheme; shock-capturing; compact scheme; conservative differencing
KeyWords Plus: FINITE-DIFFERENCE SCHEMES; EFFICIENT IMPLEMENTATION; CONSERVATION-LAWS; TURBULENCE INTERACTION; NONLINEAR SCHEMES; COMPACT SCHEME; WENO SCHEME; RESOLUTION; SIMULATION; FLOW

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学科类别: Computer Science; Physics

Physical analysis and numerical simulation for the dynamic behaviour of vehicles in pitching oscillations or rocking motions

Zhang, HX (Zhang HanXin); Zhao, Z (Zhao, Zhang); Yuan, XX (Yuan XianXu); Wei, L (Wei, Liu); Xie, YF (Xie YuFei); Ye, YD (Ye YouDa)

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摘要: Analytical methods of nonlinear dynamics and numerical simulations for the coupling equations of Navier-Stokes and flight mechanics are used to study the dynamic behaviour of pitching motions of reentry capsules with the variation of Mach number, and rocking motions of swept wings with the variation of angle of attack. Conditions under which the dynamic instability, Hopf bifurcation and saddle-node bifurcation occur are obtained. The node-saddle-node topological structure in the phase portrait, i.e. the state of bi-attractors (attracting basins) is described. The evolving process of dynamic behaviour and flow fields are given. The theories are compared with some numerical simulations conducted by the authors. Besides, some verifiable experimental results are cited. The agreement between them is very well.

文献类型: Article 语种: English

作者关键词: physical analysis; numerical simulation; pitching oscillation; rocking motion; bifurcation

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学科类别: Engineering; Materials Science

Investigation on the aerodynamic performance of an ejection seat

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来源出版物: AERONAUTICAL JOURNAL 卷: 111 期: 1120 页: 373-380 出版年: JUN 2007

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摘要: A unique experimental method is used, in combination with numerical calculation and engineering estimation, to study the aerodynamic performance of an ejection seat at $M = 0.60$, 0.90 and 1.20 , angles-of-attack $\alpha = 0$ degrees similar to 360 degrees, and sideslip angles $\beta = 0$ degrees similar to 90 degrees. Several basic characteristics of the aerodynamic performance are explored. The normal force of the ejection seat varies in a sinusoidal way and the axial force in a cosinoidal way, with the angle-of-attack. The model is statically unstable longitudinally at most attitude angles and the longitudinal stability could be improved by a stabiliser. These characteristics result from a large low pressure area caused by the leeward separation and the windward high pressure area in the ejection seat flow field, at all α , due to the blunt configuration. A set of engineering calculation formulae is deduced, based on the aerodynamic characteristics of the ejection seat.

文献类型: Article 语种: English

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Web of Science 分类: Engineering, Aerospace

学科类别: Engineering

Developing shock-capturing difference methods

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摘要: A new shock-capturing method is proposed which is based on upwind schemes and flux-vector splittings. Firstly, original upwind schemes are projected along characteristic directions. Secondly, the amplitudes of the characteristic decompositions are carefully controlled by limiters to prevent non-physical oscillations. Lastly, the schemes are converted into conservative forms, and the oscillation-free shock-capturing schemes are acquired. Two explicit upwind schemes (2nd-order and 3rd-order) and three compact upwind schemes (3rd-order, 5th-order and 7th-order) are modified by the method for hyperbolic systems and the modified schemes are checked on several one-dimensional and two-dimensional test cases. Some numerical solutions of the schemes are compared with those of a WENO scheme and a MP scheme as well as a compact-WENO scheme. The results show that the method with high order accuracy and high resolutions can capture shock waves smoothly.

文献类型: Article 语种: English

作者关键词: high order scheme; shock-capturing; upwind scheme; compact scheme; high resolution; conservative scheme

KeyWords Plus: EFFICIENT IMPLEMENTATION; SCHEMES

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学科类别: Mathematics; Mechanics

Role of on-board discharge in shock wave drag reduction and plasma cloaking

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来源出版物: CHINESE PHYSICS 卷: 16 期: 1 页: 186-192 出版年: JAN 2007

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摘要: In the present paper, a physical model is proposed for reducing the problem of the drag reduction of an attached bow shock around the nose of a high-speed vehicle with on-board discharge, to the problem of a balance between the magnetic pressure and gas pressure of plane shock of a partially ionized gas consisting of the environmental gas around the nose of the vehicle and the on-board discharge-produced plasma. The relation between the shock strength and the discharge-induced magnetic pressure is studied by means of a set of one-fluid, hydromagnetic equations reformed for the present purpose, where the discharge-induced magnetic field consists of the electron current (produced by the discharge)-induced magnetic field and the partially ionized gas flow-induced one. A formula for the relation between the above parameters is derived. It shows that the discharge-induced magnetic pressure can minimize the shock strength, successfully explaining the two recent experimental observations on attached bow shock mitigation and elimination in a supersonic flow during on-board discharge [Phys. Plasmas 9 (2002) 721 and Phys. Plasmas 7 (2000) 1345]. In addition, the formula implies that the shock elimination leaves room for a layer of higher-density plasma rampart moving around the nose of the vehicle, being favourable to the plasma radar cloaking of the vehicle. The reason for it is expounded.

文献类型: Article 语种: English

作者关键词: attached bow shock and magnetohydrodynamic (MHD) drag reduction; on-board discharges; plasma cloaking; MHD and fluid equation

KeyWords Plus: GAS; FLOW; SLAB

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Web of Science 分类: Physics, Multidisciplinary

学科类别: Physics

Experimental investigation on electromagnetic scattering of hypersonic sphere and ionized wake

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摘要: The paper presents RCS results at X band and Ka waveband radar system of steel sphere models with 10mm diameter and aluminium sphere models with 10mm diameter and 15mm diameter. The model velocities exceed 5km/s, and the experiment pressure range is 3173Pa to 11219Pa. The electromagnetic scattering properties of hypersonic spheres and wakes at X waveband monostatic mode and Ka waveband bistatic mode are obtained. The results present that the RCS of non-ablation sphere models and ablation sphere mode-Is is larger than the RCS of their ionized wakes, and the sphere models signals at X waveband radar are easily separated from their ionized wakes, and measured wake signals at X waveband radar are easily distinguished from background.

文献类型: Proceedings Paper 语种: English

作者关键词: ballistic range; sphere model; electromagnetic scattering; measurement

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Web of Science 分类: Computer Science, Hardware & Architecture; Engineering, Electrical & Electronic; Optics; Telecommunications

学科类别: Computer Science; Engineering; Optics; Telecommunications

The decrease of the radar cross section of hypersonic model

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来源出版物: IEEE 2007 INTERNATIONAL SYMPOSIUM ON MICROWAVE, ANTENNA, PROPAGATION AND EMC TECHNOLOGIES FOR WIRELESS COMMUNICATIONS, VOLS I AND II
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会议: IEEE International Symposium on Microwave, Antenna, Propagation and EMC Technologies for Wireless Communications 会议地点: Hangzhou, PEOPLES R CHINA 会议日期: AUG 14-17, 2007 会议赞助商: IEEE Beijing Sect; IEEE Commun Soc; IEEE AP Soc; IEEE ED Soc; IEEE EMC Soc; IEEE MIT Soc; IEEE SP Soc; IEEE Reg 10; Beijing Jiaotong Univ; Hangzhou Diazi Univ

摘要: To research the effect of plasma, the radar cross section (RCS) of a hypersonic model is measured in our light gas gun. The spectrum of the received signal and one-dimensional radar image of the model are given. According to this experiment, three-dimensional (3-D) finite-difference time-domain (FDTD) simulations are performed for calculating microwave scattering from a plasma-cloaked conducting model.

文献类型: Proceedings Paper 语种: English

作者关键词: plasma; hypersonic; FDTD; radar cross section (RCS); light gas gun

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学科类别: Computer Science; Engineering; Optics;

Novel approach for tracking and recognizing dim small moving targets based on probabilistic data association filter

Li, ZZ (Li, Zhengzhou); Jin, G (Jin, Gang); Dong, NL (Dong, Nengli)

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摘要: While tracking dim and small moving targets in the electro-optical (EO) tracking system, the numerous false alarms resulted from the low signal-to-noise ratio would seriously debase the performance of target recognition and tracking. The probabilistic data association filter in conjunction with a maximum likelihood approach (PDAF-ML) has been applied effectively to low observable or dim target motion analysis. Whereas, the PDAF-ML supposes that the amplitude of target is not correlative among different sampling instants, and that the greater the amplitude value is, the greater the probability of being the target of interest would be. In the EO imaging tracking system, the amplitude information and the motion of target are consistent and highly correlative in a short period. To resolve the problem that the PDAF-ML is inconsistent with the EO imaging tracking system, the two features, namely, the amplitude information and the motion as well as their consistency, are modeled as Markov stationary random signals and are fused by means of PDAF. Experiments are carried out, and the results show that, with the proposed approach, the uncertainty of trajectory association would be largely decreased, and the performance of target recognition and tracking could be significantly improved. (c) 2007 Society of Photo-Optical Instrumentation Engineers.

文献类型: Article 语种: English

作者关键词: dim and small moving target; target recognition and tracking; probabilistic data association filter; multifeature fusion

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学科类别: Optics

The Numerical Research on the transition of the Three-Dimensional Supersonic spatial developing mixing layer when $Mc=0.5$

Li, Q (Li, Q.)¹; Deng, XB (Deng, X. B.)¹; Zhang, HX (Zhang, H. X.)¹

来源出版物: NEW TRENDS IN FLUID MECHANICS RESEARCH: PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON FLUID MECHANICS:198-201DOI: 10.1007/978-3-540-75995-9_59 出版年: 2007

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会议: 5th International Conference on Fluid Mechanics 会议地点: Shanghai, PEOPLES R CHINA 会议日期: AUG 15-19, 2007会议赞助商: Chinese Soc Theoret & Appl Mech; Shanghai Jiao Tong Univ; Gesell Angewandte Math & Mech; Bioengn Div; Fluid Engn Div; Engn Mech Div; KC Wong Educ Fdn; Natl Nat Sci Fdn China; Inst Mech, Chinese Acad Sci; Hong Kong Soc Theoret & Appl Mech; Hong Kong Inst Sci; Shanghai Soc Theoret & Appl Mech

摘要: In this paper, a fourth order difference scheme based on frequency spectrum relation preservation and developed boundary processing methods are used to make simulations on the three-dimensional supersonic spatial developing mixing layer when the convective Mach number $Mc=0.5$. The researches show that, when imposing three-dimensional disturbances, large scale vortices sizes are developed and the flow evolves into turbulence by transition finally. In the process, flow patterns are characterized as the vortex splitting, vortex ribs and hairpin vortices, and the flow evolves into turbulence through the lift-up and breakdown of hairpin vortices. The preliminary statistics show that the flow has the features of turbulence through statistical analysis. The simulations also show that, the vortex-pairing patterns are absent in the evolution of the mixing layer unlike the two-dimensional counterparts, new features especially like the vortex splitting and stream-wise vortices (ribs and hairpin vortices) are dominant in the evolving process.

文献类型: Proceedings Paper 语种: English

作者关键词: mixing layers; numerical simulations; vortex; transition; turbulence

KeyWords Plus: EVOLUTION; SCALE

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Web of Science 分类: Engineering, Environmental; Mechanics

学科类别: Engineering; Mechanics

Study on icing test scaling law

Yi, X (Yi, X.)¹; Zhu, GL (Zhu, G. L.)¹

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摘要: A modified icing scaling law, derived from the basic process of ice accretion on aircraft surface, is proposed in this paper. Numerical method is used for evaluation of the modified icing scaling law. In performing the evaluation, ice accretion on a cylinder is numerically simulated with parameters determined by the scaling law. The computational results show that ice shapes on full-scale cylinder and its sub-scaled model are similar, which illustrates that the law is valid, and it can be used in ice wind tunnel test as the theoretic basis of test and its parameters selection.

文献类型: Proceedings Paper 语种: English

作者关键词: ice accretion; icing scaling law; numerical simulation; ice wind tunnel

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Web of Science 分类: Engineering, Environmental; Mechanics

学科类别: Engineering; Mechanics

Numerical simulations for insect 'Clap and Fling' with unsteady incompressible solver on dynamic hybrid grids

Zhang, LP (Zhang, L. P.)¹; Chang, XH (Chang, X. H.)¹; Duan, XP (Duan, X. P.)¹; Zhang, HX (Zhang, H. X.)¹

来源出版物: NEW TRENDS IN FLUID MECHANICS RESEARCH: PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON FLUID MECHANICS 页 : 634-637 DOI: 10.1007/978-3-540-75995-9_211 出版年: 2007

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摘要: For very insect such as tiny wasp Encarsaria Formosa, Weis-Fogh found that the 'clap-fling' mechanism of their wings is the main cause for their large lift. In this paper, we simulate the motion numerically and analyze the generation of large lift by the wings with an unsteady incompressible flow solver based on dynamic hybrid mesh. Both one wing flapping and two wings 'clap and fling' are considered in the Reynolds number range of 8 similar to 128, the difference on flow structures and aerodynamic forces are compared with each other, and then high lift mechanism is analyzed.

文献类型: Proceedings Paper 语种: English

作者关键词: clap-fling; dynamic hybrid mesh; unsteady incompressible flow; bio-fluid dynamics

KeyWords Plus: HOVERING MODEL HAWKMOTH; FLIGHT; VORTEX

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Web of Science 分类: Engineering, Environmental; Mechanics

学科类别: Engineering; Mechanics

Interaction of an oblique shock wave with a pair of parallel vortices: Shock dynamics and mechanism of sound generation

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来源出版物: PHYSICS OF FLUIDS 卷:18 期:12 文献号:126101 DOI:10.1063/1.2391806 出版年: DEC 2006
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摘要: The interaction between an oblique shock wave and a pair of parallel vortices is simulated systematically through solving the two-dimensional, unsteady compressible Navier-Stokes equations using a fifth order weighted essentially nonoscillatory finite difference scheme. The main purpose of this study is to characterize the flow structure and the mechanism of sound generation in the interaction between an oblique shock wave and a pair of vortices. We study two typical shock waves of Mach number $M_s=1.2$ and $M_s=1.05$, which correspond to two typical shock structures of Mach reflection and regular reflection, respectively, in the problem of shock-vortex interaction. The effects of the strength of the vortices and the geometry parameters are investigated. In addition, we have also considered both cases of passing and colliding vortex pairs. The interaction is classified into four types for the passing case and seven types for the colliding case according to different patterns of the shock structure. Our simulation shows that the sound field is the result of three mechanisms. The first mechanism is related directly to the interaction of the shock wave and the pair of vortices. The second mechanism is related to the coupling process of the vortex pair. The third mechanism is related to the interaction of the reflected shock waves and sound waves. The first mechanism is dominating if the vortex pair is weak. The combination of the first and the second mechanisms is dominating if the vortex pair is of moderate strength. If the vortex pair is strong, the acoustic field is also significantly affected by the interaction of the reflected shock waves and sound waves. (c) 2006 American Institute of Physics.

文献类型: Article 语种: English

KeyWords Plus: VORTEX INTERACTION; EFFICIENT IMPLEMENTATION; TURBULENCE INTERACTION; ACOUSTIC-WAVE; SCHEMES; RESOLUTION

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Web of Science 分类: Mechanics; Physics, Fluids & Plasmas

学科类别: Mechanics; Physics

Ejection seat test techniques in a high-speed wind tunnel

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学科类别: Engineering

Numerical simulation and physical characteristics analysis for slender wing rock

Liu, W (Liu, W); Zhang, HX (Zhang, HX); Zhao, HY (Zhao, HY)

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KeyWords Plus: DELTA-WINGS

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Web of Science 分类: Engineering, Aerospace

学科类别: Engineering

Adaptive depth control for autonomous underwater vehicles based on feedforward neural networks

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会议日期: AUG 16-19, 2006 会议赞助商: IEEE Computat Intelligence Soc; Int Neural Network Soc; Natl Sci Fdn China

摘要: This paper studies the design and application of the neural network based adaptive control scheme for autonomous underwater vehicle's (AUV's) depth control system that is an uncertain nonlinear dynamical one with unknown nonlinearities. The unknown nonlinearity is approximated by a feedforward neural network whose parameters are adaptively adjusted on-line according to a set of parameter estimation laws for the purpose of driving the AUV to cruise at the preset depth. The Lyapunov synthesis approach is used to develop the adaptive control scheme. The overall control system can guarantee that the tracking error converges in the small neighborhood of zero and all adjustable parameters involved are uniformly bounded. Simulation examples are given to illustrate the design procedure and the applicability of the proposed method. The results indicate that the proposed method is suitable for practical applications.

文献类型: Article; Proceedings Paper 语种: English

KeyWords Plus: ROBOTIC VEHICLES

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学科类别: Automation & Control Systems; Computer Science

Gas kinetic algorithm for flows in Poiseuille-like microchannels using Boltzmann model equation

Li, ZH (Li, ZH); Zhang, HX (Zhang, HX); Fu, S (Fu, S)

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摘要: The gas-kinetic unified algorithm using Boltzmann model equation have been extended and developed to solve the micro-scale gas flows in Poiseuille-like micro-channels from Micro-Electro-Mechanical Systems (MEMS). The numerical modeling of the gas kinetic boundary conditions suitable for micro-scale gas flows is presented. To test the present method, the classical Couette flows with various Knudsen numbers, the gas flows from short microchannels like plane Poiseuille and the pressure-driven gas flows in two-dimensional short microchannels have been simulated and compared with the approximate solutions of the Boltzmann equation, the related DSMC results, the modified N-S solutions with slip-flow boundary theory, the gas-kinetic BGK-Burneft solutions and the experimental data. The comparisons show that the present gas-kinetic numerical algorithm using the mesoscopic Boltzmann simplified velocity distribution function equation can effectively simulate and reveal the gas flows in microchannels. The numerical experience indicates that this method may be a powerful tool in the numerical simulation of micro-scale gas flows from MEMS.

文献类型: Article 语种: English

作者关键词: Boltzmann model equation; discrete velocity ordinate method; finite-difference scheme; Couette flow; Poiseuille flow; gas flow in short-microchannel

KeyWords Plus: SIMULATION; CONTINUUM; SPEED

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学科类别: Physics

Construction of third-order WNND scheme and its application in complex flow

Liu, W (Liu, W); Zhao, HY (Zhao, HY); Xie, YF (Xie, YF)

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摘要: According to the Liu's weighted idea, a space third-order WNND (weighted non-oscillatory, containing no free parameters, and dissipative scheme) scheme was constructed based on the stencils of second-order NND (non-oscillatory, containing no free parameters, and dissipative scheme) scheme. It was applied in solving linear-wave equation, 1 D Euler equations and 3 D Navier-Stokes equations. The numerical results indicate that the WNND scheme which does not increase interpolated point (compared to NND scheme) has more advantages in simulating discontinues and convergence than NND scheme. Applying WNND scheme to simulating the hypersonic flow around lift-body shows: With the AoA (angle of attack) increasing from 0degrees to 50degrees, the structure of limiting streamline of leeward surface changes from unseparating, open-separating to separating, which occurs from the combined-point (which consists of saddle and node points). The separating area of upper wing surface is increasing with the AoA's increasing. The topological structures of hypersonic flowfield based on the sectional flow patterns perpendicular to the body axis agree well with Zhang Hanxin's theory. Additionally, the unstable-structure phenomenon which is showed by two saddles connection along leeward symmetry line occurs at some sections when the AoA is bigger than 20degrees.

文献类型: Article 语种: English

作者关键词: high-order scheme; numerical simulation; topological structure; limiting streamline of surface; Navier-Stokes equation; WNND scheme

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学科类别: Mathematics; Mechanics

A gas kinetic algorithm for flows in microchannel

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摘要: A gas-kinetic numerical algorithm using the molecular velocity distribution function equation is developed and extended to solve the gas flows in micro-channels. Based on the kinetic Shakhov model, the velocity distribution function equation is used to describe the micro-scale gas flows with various Knudsen numbers. The gas-kinetic finite difference scheme based on the unsteady time-splitting technique is constructed to directly solve the discrete velocity distribution functions. The numerical modeling of the gas kinetic boundary conditions is presented. The numerical integration method for the discrete velocity space is developed to evaluate the macroscopic flow parameters at each point in the physical space. To verify the present method, the classical Couette flows with various Knudsen numbers, the pressure-driven Poiseuille flow in two-dimensional short micro-channel are simulated and compared with the approximate solutions of the linearized Boltzmann equation.

文献类型: Article 语种: English

作者关键词: Boltzmann model equation; velocity distribution function; discrete velocity ordinate method; finite-difference scheme; micro-scale gas flow

KeyWords Plus: SIMULATION MONTE-CARLO; RAREFIED FLOW; FLUID-FLOWS; MEMS; COMPUTATIONS; CONTINUUM; EQUATIONS; SPEED; SLIP; CHIP

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学科类别: Engineering; Mathematics; Mechanics; Physics

Measurement and calculation of vibrational temperature behind strong shock waves

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会议: 24th International Symposium on Shock Waves 会议地点: Beijing, PEOPLES R CHINA 会议日期: JUL 11-16, 2004 会议赞助商: Chinese Acad Sci, Inst Mech; Nat Sci Fdn China; Chinese Soc Shock Waves; Chinese Soc Theoret & Appl Mech; Chinese Soc Aerodynam

摘要: In the present paper the measured values of vibrational temperature behind strong shock waves are compared with theoretical ones. The histories of vibrational temperature behind strong shock waves in a shock tube were measured using two monochromators. The test gas was pure nitrogen at 100-300Pa, and the speeds of shock waves were 5.0-6.0km/s. The electronic temperature of N-2(+) was also approximately determined from experiment and compared with the experimental vibrational temperature. The results show that the presented calculational method is effective, and the electronic energy of N2+ is excited much faster than its vibrational energy. One Langmuir probe was used to determine the effective time of region 2. The influence of viscosity in the shock tube is also analyzed.

文献类型: Proceedings Paper 语种: English

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Web of Science 分类: Mechanics

学科类别: Mechanics

Impulse combustion tunnel and its application in experimental research of scramjet

He, W (He, W); Tan, Y (Tan, Y); Li, XD (Li, XD); Liu, WX (Liu, WX); Le, JL (Le, JL)

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会议: 24th International Symposium on Shock Waves 会议地点: Beijing, PEOPLES R CHINA 会议日期: JUL 11-16, 2004 会议赞助商: Chinese Acad Sci, Inst Mech; Nat Sci Fdn China; Chinese Soc Shock Waves; Chinese Soc Theoret & Appl Mech; Chinese Soc Aerodynam

摘要: In this paper, a new type of impulse combustion tunnel for scramjet test is introduced and the principle of its operation is described. Experimental results from hundreds of scramjet tests for hydrogen and kerosene demonstrate that this tunnel is suitable for scramjet research.

文献类型: Proceedings Paper 语种: English

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学科类别: Mechanics

Massively parallel computation of three-dimensional scramjet combustor

Zheng, ZH (Zheng, ZH); Le, JL (Le, JL)

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JUL 11-16, 2004 会议赞助商: Chinese Acad Sci, Inst Mech; Nat Sci Fdn China; Chinese Soc Shock Waves;
Chinese Soc Theoret & Appl Mech; Chinese Soc Aerodynam

摘要: Recent progress of computational study of scramjet combustor has been described in Refs 1-3. However, detailed flow properties, especially the lateral properties and the sidewall effects are not considered. In this paper, a parallel simulation of an experimental dual-mode scramjet combustor configuration is presented, considering the jet-to-jet symmetry and the full-duct modeling. Turbulence is modeled with the k-epsilon two-equation turbulence model and a 7-specie, 8-equation kinetics model is used to model hydrogen/air combustion. The conservation form of the Navier-Stokes equations with finite-rate chemistry reactions is solved using a diagonal implicit finite-volume method. For the two cases, the three-dimension flow-fields with equivalence ratio $\Phi=0.0$ and 0.35 have been respectively simulated on the COW and MPP. Wall pressure comparisons between CFD and experiments (CARDIC and NAL) show fair agreement for the jet-to-jet case. For the full-duct modeling, more detailed flow properties are obtained. The fuel-penetrating heights of the injectors are different because of the effects of the sidewall boundary layer and the shock wave in the combustor. According to numerical results, if adjusting the locations of the injectors, the combustion efficiency could be improved.

文献类型: Proceedings Paper 语种: English

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学科类别: Mechanics

Time requirements for scramjet performance study with fuel of kerosene

Le, JL (Le, JL); Liu, WX (Liu, WX); Tan, Y (Tan, Y); He, W (He, W)

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Chinese Soc Theoret & Appl Mech; Chinese Soc Aerodynam

文献类型: Proceedings Paper 语种: English

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学科类别: Mechanics

Microchannel flow in the slip regime: gas-kinetic BGK-Burnett solutions

Xu, K (Xu, K); Li, ZH (Li, ZH)

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出版年: AUG 25 2004

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摘要: In the first part of this paper presents a gas-kinetic scheme based on the Bhatnagar-Gross-Krook (BGK) model for the microflow simulations in the near continuum flow regime. The current method improves the previous gas-kinetic BGK Navier-Stokes (BGK-NS) solver by (i) implementing a general non-equilibrium state based on the Chapman-Enskog expansion of the BGK model up to the Knudsen number squared (Kn^2) in the gas distribution function, (ii) using the compatibility condition to evaluate all high-order time derivative terms in the Chapman-Enskog expansion, and (iii) implementing the kinetic boundary condition for the gas distribution function to obtain 'slip' boundary automatically. As a result, the gas-kinetic BGK-Burnett scheme improves the validity of the BGK-NS solver for the microchannel flow simulations even in the slip flow regime, where the Navier-Stokes equations with the slip boundary conditions are considered to be legitimately valid. Owing to the correction to the heat transport in the energy flux, the Prandtl number in the gas-kinetic BGK-Burnett method can take any value to capture both viscous and heat conduction effects. Since the current method is based on the direct evaluation of the gas distribution function and captures its time evolution, it is different from those methods that are based on the macroscopic Burnett or extended hydrodynamic equations. The second part of this paper is about the application of the newly developed gas-kinetic BGK-Burnett method in the microchannel flows. First, we verify the method in the pressure- and external-force-driven Poiseuille flows, where the reliable direct simulation Monte Carlo (DSMC) results are available. In the study of Poiseuille flow with $Kn = 0.1$, the qualitative differences in the pressure distribution in the cross-stream direction between the Navier-Stokes and the DSMC results are resolved by the gas-kinetic BGK-Burnett scheme. It demonstrates that the BGK-Burnett method could give a more realistic description of flow motion than the Navier-Stokes method even in the slip flow regime. After that, the current method is used to simulate the microchannel flows, where the experimental data are available. In this study, the similarity in the pressure distribution along the straight microchannel is verified first. Then, the mass flow rates for different gases, such as argon, helium and nitrogen, in the long microchannel of submicron height are computed and compared with the experimental measurements.

文献类型: Article 语种: English

KeyWords Plus: SIMULATION MONTE-CARLO; POISEUILLE FLOW; NAVIER-STOKES; RAREFIED-GAS; CONTINUUM; TRANSITION; EQUATIONS; CHANNELS; SCHEMES; MICRO
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A block LU-SGS implicit dual time-stepping algorithm for hybrid dynamic meshes

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摘要: A block lower upper symmetric Gauss-Seidel (BLU-SGS) implicit dual time-stepping method is developed for moving body problems with hybrid dynamic grids. To simulate flows over complex configurations, a hybrid grid method is adopted in this paper. Body-fitted quadrilateral (quad) grids are generated first near solid bodies. An adaptive Cartesian mesh is then generated to cover the entire computational domain. Cartesian cells which overlap the quad grids are removed from the computational domain, and a gap is produced between the quad grids and the adaptive Cartesian grid. Finally triangular grids are used to fill this gap. With the motion of moving bodies, the quad grids move with the bodies, while the adaptive Cartesian grid remains stationary. Meanwhile, the triangular grids are deformed according to the motion of solid bodies with a 'spring' analogy approach. If the triangular grids become too skewed, or the adaptive Cartesian grid crosses into the quad grids, the triangular grids are regenerated. Then the flow solution is interpolated from the old to the new grid. The fully implicit equation is solved using a dual time-stepping solver. A Godunov-type scheme with Roe's flux splitting is used to compute the inviscid flux. Several sub-iteration schemes are investigated in this study. Both supersonic and transonic unsteady cases are tested to demonstrate the accuracy and efficiency of the method. (C) 2004 Elsevier Ltd. All rights reserved.

文献类型: Article 语种: English

KeyWords Plus: ADVANCING-FRONT METHOD; UNSTRUCTURED GRIDS; FLOW COMPUTATIONS; EULER EQUATIONS; GENERATION; SCHEME

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Gas kinetic algorithm using Boltzmann model equation

Li, ZH (Li, ZH); Zhang, HX (Zhang, HX)

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摘要: Based on the Boltzmann-BGK model equation, the unified simplified velocity distribution function equation adapted to various flow regimes can be presented by the aid of the basic characteristic on molecular movement and collision approaching to equilibrium. The optimum Golden Section principle is extended and applied to the discrete velocity ordinate method in order to discretize the corresponding velocity components, and then the molecular velocity distribution function equation will be cast into hyperbolic conservation laws form with non-linear source terms. In view of the unsteady characteristic of molecular convective movement and colliding relaxation, the time-splitting method is applied to decompose the velocity distribution function equations into the colliding relaxation equations with non-linear source terms and the convective motion equations. Based on the second-order Runge-Kutta method and the non-oscillatory, containing no free parameters, and dissipative (NND) finite difference method, the gas kinetic finite difference second-order scheme is constructed to directly solve the discrete velocity distribution functions. Four types of discrete velocity quadrature rules, such as the modified Gauss-Hermite formula and the Golden Section number-theoretic integral method, are developed and applied to evaluate the macroscopic flow moments of the distribution functions over the velocity space. As a result, a unified gas kinetic algorithm is established for the flows from rarefied transition to continuum regime. To test the reliability of the present method, the one-dimensional shock wave structures, the flows past two-dimensional circular cylinder and the three-dimensional flows over sphere with various Knudsen numbers are simulated. The computational results are found in high resolution of the flow fields and good agreement with the theoretical, DSMC, and experimental results. (C) 2003 Elsevier Ltd. All rights reserved.

文献类型: Article 语种: English

KeyWordsPlus:NUMBER-THEORETICMETHOD;NUMERICAL-ANALYSIS;NIFORM-DISTRIBUTION;
BGK SCHEME; FLOWS; SIMULATION; QUADRATURE

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学科类别: Computer Science; Mechanics

Study on gas kinetic unified algorithm for flows from rarefied transition to continuum

Li, ZH (Li, ZH); Zhang, HX (Zhang, HX)

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摘要: The modified BGK equation adapted to various flow regimes can be presented by the aid of the basic characteristics on molecular movement and collision approaching to equilibrium. The discrete velocity ordinate method is developed and applied to the velocity distribution function to remove its continuous dependency on the velocity space, and then the velocity distribution function equation is cast into hyperbolic conservation law form with nonlinear source terms. Based on the unsteady time-splitting method and the non-oscillatory, containing no free parameters, and dissipative (NND) scheme, the gas kinetic finite difference second-order scheme is constructed for the computation of the discrete velocity distribution functions. The mathematical model on the interaction of molecules with solid surface is studied and used in the numerical method. Four types of numerical quadrature rules, such as the modified Gauss-Hermite formula, the composite Newton-Cotes integration method, the Gauss-Legendre numerical quadrature rule, and the Golden Section number-theoretic integral method, are developed and applied to the discretized velocity space to evaluate the macroscopic flow parameters at each point in the physical space. As a result, a unified simplified gas kinetic algorithm is established for the flows from rarefied transition to continuum regime. Based on analyzing the inner parallel degree of the unified algorithm, the parallel strategy adapted to the gas kinetic numerical algorithm is studied, and then the HPF parallel processing software for the unified algorithm is developed. To test the present method, the one-dimensional shock-tube problems, the flows past two-dimensional circular cylinder, and the flows around three-dimensional sphere and spacecraft shape with various Knudsen numbers are simulated. The computational results are found in high resolution of the flow fields and good agreement with the theoretical, DSMC, N-S, and experimental results. (C) 2003 Elsevier B.V. All rights reserved.

文献类型: Article 语种: English

作者关键词: kinetic theory of gases; velocity distribution function; Boltzmann model equation; discrete ordinate method; time-splitting method; NND finite difference scheme; rarefied gas flow; continuum flow

KeyWords Plus: MODEL BOLTZMANN EQUATIONS; NUMERICAL-SIMULATION; SHOCK-WAVES; QUADRATURE; SCHEMES

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学科类别: Computer Science; Physics

The development of the technique of computer simulating color-schlieren

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来源出版物: JOURNAL OF VISUALIZATION 卷: 7 期: 3 页: 225-232 出版年: 2004

被引频次: 0 (来自 Web of Science) 引用的参考文献: 5

摘要: The computer simulation study for color-schlieren is to provide a new method for validations between experiment and theory, which can get color-schlieren image from the computational flow field data. This paper gives a brief description about the theory of method, technical way, algorithm, key problem that has been solved, the computational results and the future development direction.

文献类型: Article 语种: English

作者关键词: flow visualization; color; schlieren; image processing

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学科类别: Computer Science; Imaging Science & Photographic

Technology Investigation on hypersonic heat-transfer reduction using an upstream-directed jet

Geng, XR (Geng, XR); Gui, YW (Gui, YW); He, LX (He, LX); Wang, AL (Wang, AL)

来源出版物: PROCEEDINGS OF THE 3RD INTERNATIONAL SYMPOSIUM ON HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, VOLS 1 AND 2 页: 18-21 出版年: 2004

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会议: 3rd International Symposium on Heat Transfer Enhancement and Energy Conservation 会议地点: Guangzhou, PEOPLES R CHINA 会议日期: JAN 12-15, 2004会议赞助商: Minist Educ; Natl Nat Sci Fdn China; KC Wong Educ Fdn; Guangzhou Bur Sci & Technol; Guangzhou Assoc Sci & Technol; Guangzhou Kelon Elect Holdings Co Ltd; Shunde Shenling Air conditioning Equipment Co Ltd; Five Star Solar Energy Co Ltd; S China Univ Technol, Sch Chem Engrg; Tsinghua Univ; Beijing Univ Technol

摘要: In this paper the heating rate reduction by using a forward-facing jet in front of body is researched. The influence on the heating rate reduction caused by the difference between planar flow and axisymmetric flow is investigated. It has been found that, in axisymmetric flow, local hot spot with much high heating rate will occur near the reattachment point, while there is not such phenomenon in planar flow under the same flow conditions and jet exit conditions. The phenomenon and the difference are analyzed. Finally some important conclusions are drawn.

文献类型: Proceedings Paper 语种: English

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Web of Science 分类: Thermodynamics; Energy & Fuels; Engineering, Mechanical

学科类别: Thermodynamics; Energy & Fuels; Engineering

Numerical simulation of ice accretion on airfoil

Yi, X (Yi, X); Zhu, GL (Zhu, GL)

来源出版物: RECENT ADVANCES IN FLUID MECHANICS 页: 278-283 出版年: 2004

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会议: 4th International Conference on Fluid Mechanics 会议地点: Dalian, PEOPLES R CHINA 会议日期: JUL 20-30, 2004会议赞助商: Chinese Soc Theoret & Appl Mech; Gesell Angewandte Math & Mech; US Natl Comm Biomech; ASME, Bioengn Div; ASME, Fluids Engn Div; ASME, Appl Mech Div; ASCE, Engn Mech Div; Int Soc Offshore & Polar Engineers; Japan Soc Fluid Mech; Chinese Acad Sci, Inst Mech; Chinese Aerodynam Res & Dev Ctr; Hong Kong Soc Theoret & Appl Mech; Dalian Univ Technol, State Key Lab Coastal & Offshore Engn

摘要: A method for prediction of ice accretion on airfoil and their effects on airfoil aerodynamic characteristics is described. The flow field is calculated by solving the 2D steady incompressible N-S equations with finite volume method. A 4-order Runge-Kutta method is used to solve the droplet trajectory equation. Assuming ice grows in the direction normal to the surface, rime ice shape is determined with the assumption that all droplets freeze at their points of impact and glaze ice shape is obtained after solving the mass and energy equations that describe the thermodynamic process of ice accretion. The method yields ice shapes that are in good agreement with the results found in the literatures. Computational consequences for aerodynamic properties of iced airfoil show that ice accretion has undesirable effects on airfoil performance.

文献类型: Proceedings Paper 语种: English

作者关键词: flowfield calculation; droplet trajectory equations; ices accretion

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Web of Science 分类: Mechanics

学科类别: Mechanics

Integrated fluid-thermal analysis methods and application to complex configuration

Geng, XR (Geng, XR); Gui, YW (Gui, YW); Wang, AL (Wang, AL); He, LX (He, LX)

来源出版物: PROCEEDINGS OF THE 3RD INTERNATIONAL SYMPOSIUM ON HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, VOLS 1 AND 2 页: 1519-1524 出版年: 2004

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摘要: An integrated fluid-thermal analysis method has been developed and applied to the study on numerical simulation of thermal response due to aerodynamic heating. Benchmark solutions are calculated and compared with available results to validate the method presented in the paper. The method is also applied to three-dimensional flow-field around and thermal response on supersonic aircraft. The study succeeds in demonstrating the high efficiency of the new integrated method, and the cases with turbulent effects considered are still to be studied in the future yet.

文献类型: Proceedings Paper 语种: English

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Web of Science 分类: Thermodynamics; Energy & Fuels; Engineering, Mechanical

学科类别: Thermodynamics; Energy & Fuels; Engineering

Transonic flutter predications using CFD method for airplane configurations

Luo, JG (Luo, JG); Zhang, JB (Zhang, JB); Guan, D (Guan, D)

来源出版物: RECENT ADVANCES IN FLUID MECHANICS 页: 235-238 出版年: 2004

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会议: 4th International Conference on Fluid Mechanics 会议地点: Dalian, PEOPLES R CHINA 会议日期: JUL 20-30, 2004会议赞助商: Chinese Soc Theoret & Appl Mech; Gesell Angewandte Math & Mech; US Natl Comm Biomech; ASME, Bioengn Div; ASME, Fluids Engn Div; ASME, Appl Mech Div; ASCE, Engn Mech Div; Int Soc Offshore & Polar Engineers; Japan Soc Fluid Mech; Chinese Acad Sci, Inst Mech; Chinese Aerodynam Res & Dev Ctr; Hong Kong Soc Theoret & Appl Mech; Dalian Univ Technol, State Key Lab Coastal & Offshore Engn

摘要: A Computational Fluid Dynamics (CFD) and Computational Structural Dynamics (CSD) method is used for simulation and predication of transonic flutter for airplane configuration. The CFD solver is based on an unsteady, multi-block, multi-grid finite-difference algorithm for Euler/Navier-Stokes equations. The CSD solver is based on a second-order linearized acceleration finite-difference algorithm. A general multi-block deformation grid is used to generate dynamically moving grids for unsteady flow solver. The solution of the flow field and the structural are coupled strongly in time domain by an implicit method. The unsteady solver with the moving grid algorithm can be used easily to calculate response and flutter boundary of an aero-elastic system. And the coupled CFD-CSD method simulates the aero-elastic system directly on the time domain and is not limited to linearized solutions. It is capable of predicting damped, diverging, and neutral motions, and limit cycle and chaos oscillations of an aero-elastic system. This method is used to analysis the aero-elastic system of a wing and an xx airplane configuration.

文献类型: Proceedings Paper 语种: English

作者关键词: unsteady; computational fluid dynamics; computational structural dynamics; flutter

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学科类别: Mechanics

Numerical simulation of axisymmetric contour nozzles flowfield in scramjet test

Shi, YL (Shi, YL); Peng, ZY (Peng, ZY)

来源出版物: RECENT ADVANCES IN FLUID MECHANICS 页: 270-273 出版年: 2004

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摘要: The axisymmetric Navier-Stokes equations for contour nozzle flow field in the Scramjet test are numerically solved in this paper. The chemically nonequilibrium model of seven chemical species (H-2, N-2, O-2, H₂O, H, O, OH) and eight elementary reactions are used to determine reaction rates. The fully implicit scheme and multiple-step iteration method are adopted to simulate flowfield. The convective fluxes are solved using the second NND scheme, and the viscous fluxes are approximated using central differencing. In order to accelerate convergence, the mixed flux-splitting method is used to the convective fluxes. The chemical source terms are linearized to solve the stiff source problem. The computational results are well agreement with the data obtained with quasi one-dimensional integral method. And the flow parameters are almost the same in core region at the nozzle exit.

文献类型: Proceedings Paper 语种: English

作者关键词: Scramjet test; axisymmetric contour nozzle; numerical simulation; mixed flux splitting method

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Web of Science 分类: Mechanics

学科类别: Mechanics

Experimental study of the spanwise blowing effect on unsteady characteristics

Jiang, YB (Jiang, YB); Sun, HS (Sun, HS); Huang, Y (Huang, Y); Liu, ZT (Liu, ZT)

来源出版物: RECENT ADVANCES IN FLUID MECHANICS 页: 831-835 出版年: 2004

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摘要: The unsteady aerodynamics and vortex characteristics during large amplitude oscillation were experimentally studied in Phi3.2m subsonic wind tunnel by using of the PIV technique. The measurements were achieved utilizing a digital recording technique based on a modified CCD video camera and an evaluation process based on the cross correlation technique. Instantaneous velocity fields and streamlines showing the complex vortex could be gained from a large number of PIV images. In addition, using the spanwise blowing to control the vortex separation is also investigated. The experimental results indicate that the spanwise blowing could effectively control the vortex separation, improve the maximum lift coefficient and increase the stall angle-of-attack.

文献类型: Proceedings Paper 语种: English

作者关键词: unsteady aerodynamics; vortex; PIV; wind tunnel test

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Web of Science 分类: Mechanics

学科类别: Mechanics

Numerical investigation from rarefied flow to continuum by solving the Boltzmann model equation

Li, ZH (Li, ZH); Zhang, HX (Zhang, HX)

来源出版物: INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN FLUIDS 卷: 42 期: 4
页: 361-382 DOI: 10.1002/flid.517 出版年: JUN 10 2003

被引频次: 19 (来自 Web of Science) 引用的参考文献: 34

摘要: Based on the Bhatnagar-Gross-Krook (BGK) Boltzmann model equation, the unified simplified velocity distribution function equation adapted to various flow regimes can be presented. The reduced velocity distribution functions and the discrete velocity ordinate method are developed and applied to remove the velocity space dependency of the distribution function, and then the distribution function equations will be cast into hyperbolic conservation laws form with non-linear source terms. Based on the unsteady tith-splitting technique and the non-oscillatory, containing no free parameters, and dissipative (NND) finite-difference method, the gas kinetic finite-difference second-order scheme is constructed for the computation of the discrete velocity distribution functions. The discrete velocity numerical quadrature methods are developed to evaluate the macroscopic flow parameters at each point in the physical space. As a result, a unified simplified gas kinetic algorithm for the gas dynamical problems froth various flow regimes is developed. To test the reliability of the present numerical method, the one-dimensional shock-tube problems and the flows past two-dimensional circular cylinder with various Knudsen numbers are simulated. The computations of the related flows indicate that both high resolution of the flow fields and good qualitative agreement with the theoretical, DSMC and experimental results can be obtained. Copyright (C) 2003 John Wiley Sons, Ltd.

文献类型: Article 语种: English

作者关键词: Boltzmann model equation; gas kinetic theory; discrete velocity ordinate method; NND finite-difference scheme; rarefied gas flow; continuum flow

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Web of Science 分类: Computer Science, Interdisciplinary Applications; Mathematics, Interdisciplinary Applications; Mechanics; Physics, Fluids & Plasmas

学科类别: Computer Science; Mathematics; Mechanics; Physics

Combustion of liquid and gaseous fuels in a supersonic combustor

Le, JL (Le, JL); Bai, HC (Bai, HC); Mishunin, AA(Mishunin, AA); Starov, AV (Starov, AV)

来源出版物: COMBUSTION EXPLOSION AND SHOCK WAVES 卷: 39 期: 3 页: 292-299 DOI:
10.1023/A:1023892119527 出版年: MAY-JUN 2003

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摘要: Results of an experimental study of a full scramjet model operating on kerosene, which was performed in an IT-302M hotshot wind tunnel based at the Institute of Theoretical and Applied Mechanics of the Siberian Division of the Russian Academy of Sciences, and an experimental study of a model operating on hydrogen, which was performed in a hotshot wind tunnel with fire heating based at the China Aerodynamic Research and Development Center, are reported. The tests were performed for Mach numbers 5 and 6 for flow parameters close to in-flight conditions. An optimal system for kerosene injection under these conditions was determined, and the thrust characteristics of the engine model were examined. The possibility of controlling kerosene combustion in tests in the short-duration wind tunnel was analyzed, and special features of fuel ignition in a short combustor were considered. Intense combustion of kerosene was achieved with upstream injection of more than 3% of hydrogen, which allowed obtaining effective thrust. The distributions of static pressure and force characteristics of the model in the case of kerosene and hydrogen combustion were compared.

文献类型: Article 语种: English

作者关键词: scramjet; supersonic combustor; kerosene; thrust

KeyWords Plus: KEROSENE

通讯作者地址: Le, JL (通讯作者),China Aerodynam Res & Dev Ctr, Mianyang 621000, Peoples R China

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学科类别: Thermodynamics; Energy & Fuels; Engineering; Materials Science

High-order accurate dissipative weighted compact nonlinear schemes

Deng, XG (Deng, XG)

来源出版物: SCIENCE IN CHINA SERIES A-MATHEMATICS PHYSICS ASTRONOMY 卷: 45 期: 3
页: 356-370 出版年: MAR 2002

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摘要: Based on the method deriving dissipative compact linear schemes (DCS), novel high-order dissipative weighted compact nonlinear schemes (DWCNS) are developed, By Fourier analysis, the dissipative and dispersive features of DWCNS are discussed. In view of the modified wave number, the DWCNS are equivalent to the fifth-order upwind biased explicit schemes in smooth regions and the interpolations at cell-edges dominate the accuracy of DWCNS. Boundary and near boundary schemes are developed and the asymptotic stabilities of DWCNS on both uniform and stretching grids are analyzed. The multi-dimensional implementations for Euler and Navier-Stokes equations are discussed. Several numerical inviscid and viscous results are given which show the good performances of the DWCNS for discontinuities capturing. high accuracy for boundary layer resolutions, good convergent rates (the root-mean-square of residuals approaching machine zero for solutions with strong shocks) and especially the damping effect on the spurious oscillations which were found in the solutions obtained by TVD and ENO schemes.

文献类型: Article 语种: English

作者关键词: numerical calculation; compact schemes; nonlinear schemes; Euler equations; Navier-Stokes equations

KeyWords Plus: FINITE-DIFFERENCE SCHEMES; SHOCK-CAPTURING SCHEMES; BLUNT-BODY PROBLEM; FLOWS; SIMULATION; EQUATIONS

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Web of Science 分类: Mathematics, Applied; Mathematics

学科类别: Mathematics

Some research in application of holographic interferometry and computational flow imaging

Le, JL (Le, JL); Wu, YC (Wu, YC); Ni, HL (Ni, HL); Yang, H (Yang, H); Wu, HL (Wu, HL)

来源出版物: OPTICAL TECHNOLOGY AND IMAGE PROCESSING FOR FLUIDS AND SOLIDS DIAGNOSTICS 2002 丛书: PROCEEDINGS OF THE SOCIETY OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS (SPIE) 卷: 5058 页: 1-8 出版年: 2002

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会议: Conference on Optical Technology and Image Processing for Fluids and Solids Diagnostics 2002 会议地点: BEIJING, PEOPLES R CHINA 会议日期: SEP 03-06, 2002会议赞助商: Beijing Univ Aeronaut & Astronaut; KC Wong Educ Fdn; SPIE; Chinese Soc Theoret & Appl Mech; Chinese Aerodynam Res Soc; Visualizat Soc Japan

摘要: Two-dimensional flow visualization by laser holograph interferometry in shock tube and some applications in Computational Flow Imaging (including color interferogram and three dimensional flow) are presented.

文献类型: Proceedings Paper 语种: English

作者关键词: holograph interferometry; computational flow imaging

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Web of Science 分类: Optics

学科类别: Optics

Optical-fiber-transmission laser sheet technique for flow visualization in intermittent high speed wind tunnels

Hu, CH (Hu, CH)

来源出版物: OPTICAL TECHNOLOGY AND IMAGE PROCESSING FOR FLUIDS AND SOLIDS DIAGNOSTICS 2002 丛书: PROCEEDINGS OF THE SOCIETY OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS (SPIE) 卷: 5058 页: 344-350 出版年: 2002

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摘要: The light sheet technique provides a unique method of visualization for off-body flow fields at subsonic through supersonic speeds. But conventional mirror transmission laser systems have some shortcomings: The harsh environments of high speed wind tunnels often cause the misalignment of the optical components and the contamination of the mirror surfaces. The exposed laser beam is dangerous to the persons at the work site. This paper presents an advanced optical-fiber-transmission laser sheet system, which provides a solution to the problems above and greatly improves the quality, safety and reliability of the light sheet. The emphasis is laid on the detailed composition of the new type visualization system. Some examples of its applications in transonic/supersonic wind tunnels are also given in this paper.

文献类型: Proceedings Paper 语种: English

作者关键词: fiber optics; flow visualization; light sheet technique; vapor screen

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Web of Science 分类: Optics

学科类别: Optics

The LIF measurement for arcjet of oxygen and argon mixture gases

Yang, FR (Yang, FR); Yue, B (Yue, B); Su, T (Su, T); Yu, FM (Yu, FM)

来源出版物: OPTICAL TECHNOLOGY AND IMAGE PROCESSING FOR FLUIDS AND SOLIDS DIAGNOSTICS 2002 丛书: PROCEEDINGS OF THE SOCIETY OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS (SPIE) 卷: 5058 页: 463-469 出版年: 2002

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摘要: This paper presents applications of LIF in the flow of high temperature and high enthalpy gases: We have adopted ArF excimer to excite the rot-vib absorption lines near 193.3nm for Schumann-Runge system of Oxygen and used ultraviolet PMT to detect the fluorescence near 256nm to establish a set of LIF flow field measuring system based on ArF excimer. On the basis of LIF system we have done some research on LIF technology. We have obtained the experimental results of fluorescence signal within Oxygen Schumann-Runge system for the air at room temperature and arc-jet of oxygen and argon mixture gases. The experimental results show that the LIF measurement system based on ArF excimer has been established successfully.

文献类型: Proceedings Paper 语种: English

作者关键词: laser induced fluorescence; spectroscopy diagnostics; arc-jet

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学科类别: Optics

Research into impact effect on 3-D object of shock wave passing through curved channel and surrounding hill

Yang, H (Yang, H); Yue, MX (Yue, MX); Le, JL (Le, JL); Guo, ZL (Guo, ZL); Zhang, LH (Zhang, LH)

来源出版物: OPTICAL TECHNOLOGY AND IMAGE PROCESSING FOR FLUIDS AND SOLIDS DIAGNOSTICS 2002 丛书: PROCEEDINGS OF THE SOCIETY OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS (SPIE) 卷: 5058 页: 644-648 出版年: 2002

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摘要: The flow field of shock wave passing through curved channel and surrounding hill is investigated in a shock tube by holographic interferometry along with the quantitative measurement of the pressure distribution on the 3-D object by transducer pressure measurement technology. The test results indicate that the effect in the flow field of shock wave is the largest at the copulation of 3-D object and hill, the object leeward surface and its corner. It is significant to research into impact effect of shock wave at the complicated landform.

文献类型: Proceedings Paper 语种: English

作者关键词: shock wave; 3-D object; flow visualization; pressure measurement; holographic interferometry

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Web of Science 分类: Optics

学科类别: Optics

Development of the fully-digital DC speed regulation system in 8m X 6m Wind Tunnel

Li, DX (Li, DX); Ye, JC (Ye, JC); You, X (You, X); Zhang, XD (Zhang, XD)

来源出版物: INTERNATIONAL CONFERENCE ON SENSORS AND CONTROL TECHNIQUES (ICSC 2000) 丛书: PROCEEDINGS OF THE SOCIETY OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS (SPIE) 卷: 4077 页: 449-452 DOI: 10.1117/12.385508 出版年: 2000

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摘要: The old analog system of speed regulation of 8m x 6m wind tunnel has been successfully reformed recently. The new system realized fully digital control on 2600kW DC motor, through rebuilding two sets of 485V and 30A speed regulation equipment used in controlling large power thyristor rectifier of 2-stage serial.

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