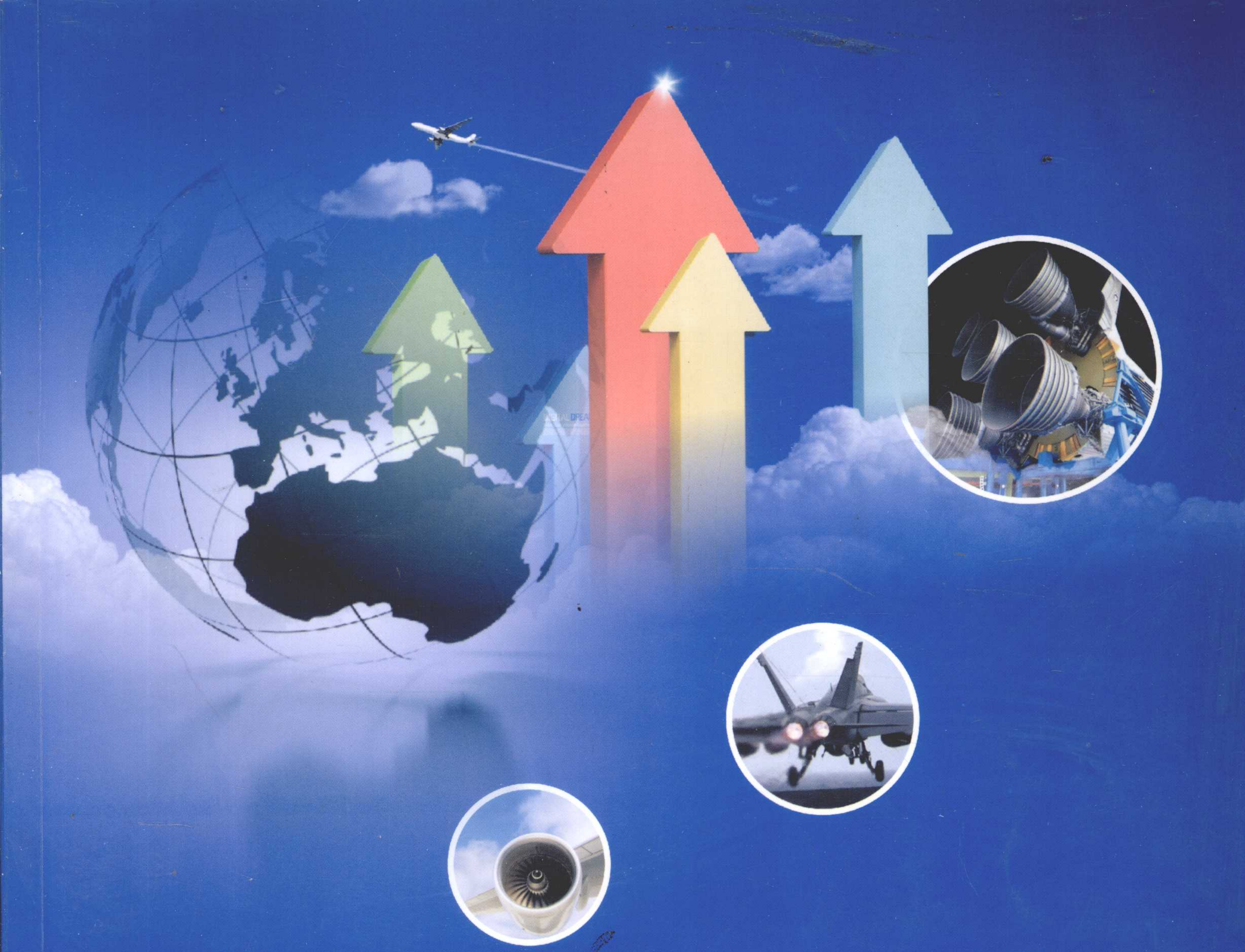

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Edited by

ISJPPE2012 Scientific Committee
Organizing Committee

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Preface

The 4th International Symposium on Jet Propulsion and Power Engineering (ISJPPE 2012) is going to be held on September 10 - 12, 2012, Xi ' an China. As the co-organizers, NPU (Northwestern Polytechnical University of China), BUAA (Beihang University of China), NUAA (Nanjing University of Aeronautics and Astronautics of China) and RWTH (Aachen University of Germany) welcome the worldwide delegates to the ISJPPE 2012.

Started in 2006, ISJPPE is jointly organized by BUAA, RWTH, NPU and NUAA. As a biennial world event on jet propulsion and power engineering, ISJPPE provides a forum for engineers, researchers, and other professionals active in these fields to review the latest progress, exchange the latest results, and learn about the most advanced theories, technologies, and applications. A broad cooperation among expertise would like to provide a further impetus to consolidate recent advances in jet propulsion and power engineering.

The International Scientific Committee of ISJPPE 2012 consists of more than 30 experts in the related fields from both academia and industry. ISJPPE 2012 received more than 180 submissions from 12 different counties. After per reviewing, 113 papers have been accepted for publication in the conference proceedings and oral presentation. These papers cover a wide range of research interest related to the jet propulsion and power, including turbomachinery, internal flow, acoustics, heat and mass transfer, multiphase flows, reacting flows, combustion, advanced materials, structural strength, vibration and reliability, and engine design, control and health management.

In addition to a large number of technical paper submissions, we are blessed with 12 invited keynote presentations given by world-renowned scientists.

On behalf of the organizing committee, we would like to express our sincere appreciations to all viewers for their timely and outstanding efforts in reviewing the large number of papers. We are grateful to all authors, committee members, conference sponsors, and financial supporters. In addition, we would like to acknowledge the support of National Natural Science Foundation of China, Grant No. 51210305026.

We hope you have a unique, rewarding and enjoyable experience at ISJPPE 2012 in Xi'an, China.

ISJPPE 2012 Scientific Committee
Organizing Committee

July, 2012

Xi'an, China

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Session A
Turbomachinery, Internal Flow and Acoustics

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Thermodinamically Compatible Conservation Laws for Working Process Simulation in High Temperature Air Breathing Engines and for Simulation of Some Nature Processes

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Abstract

The paper presents unified mathematical models of thermo-gas-dynamic process simulation for applied problems of air breathing engine creation and for theoretical analysis of some physics experimental data. In the first part of the paper we consider a coordination of thermodynamics and conservation laws by prediction of turbojet engine working process. This simulation is relevant to high class models based on real 3D geometry of turbojet engine flow path. They can be applied either in isolated unit components or in entire engine flow passage. The method of working process modeling considers all main features of engine working process (viscous and radiation losses, fuel application and combustion, air bleed and blow out, leakage from flow path, rotor and stator thermal dilatation, air humidity, rotor inertia and so on). The second part of the paper demonstrates simulation for explanation of new experimental data of modern physics. Here there are considered a few phenomenon and process which take place on a different scales (from atomic and nanotechnology scales up to astrophysical scales). We demonstrate simulations for astrophysics gamma-ray bursts, cosmic jets and dark matter.

1. Introduction

Thermogasdynamic calculations of high temperature jet and turbojet engines demands accurate simulation for detail description of whole working process, including heat addition and radiation losses in combustors and turbine. Well known experience of V generation engine creation has pointed out the imperfection of modern thermodynamic working process models (see, for example, [1-3]). The theoretically calculated in design stage engine parameters essentially differ from experimental data for first engine units. Hence, long and expensive development of new high temperature jet and gas turbine engines is required.

In the first part we consider simulation of complex working processes of jet engine different types. Here the paper present the gas dynamics model for the radiation components, the close systems of thermodynamic coordinated conservation laws and typical results for a turbojet engine simulation.

The second part of the paper demonstrates simulation for explanation of a few experimental results of modern physics and astrophysics. We demonstrate solutions for cosmic jet engines [4 - 6], gamma-ray bursts and a black hole model [7 - 9].

Achievements in experimental physics and nanothecnologies (see, for example, [10 - 12]) pointed out also that it would be useful additionally to study molecular and atomic structures. Registration of Cosmic Microwave Background Radiation (CMBR) is among such achievements. The results of conducted researches indicated that frequency distribution of background radiation density corresponds to frequency distribution of radiation density from the black body with its temperature $T=2.735$ K (near 3 K).

The second significant achievement is the discovery of Dark Matter (DM), which is also called "the hidden mass in the Universe". Now we know that 96% whole matter in our Metagalaxy consists of DM. The baryonic substance accounts to only 4%. There were multiple attempts to describe the nature of DM, but none was successful yet (see, in particular, [13 - 15]).

The third important success is the discovery of vacuum polarization around electrons, protons and atomic centers. Intensive light impulse propagation leads to creation of electron-positron pair at the collision of two powerful electromagnetic pulses [16].

Possibility to determine the shape of separate atoms and molecules via scanning probe microscopy is the fourth important for us achievement of experimental physics. It became possible to see so called vander Waals spheres and real polarized space around atomic centers within van der Waals spheres.

Using emphasized achievements the more accurate simulation for nuclear, atomic and molecule structures have been considered in our paper. The equation for description of electrical potential distribution in polarized space is provided. We analyze the specific solution in polarized space of electron and proton with the presence of some barriers, which allow electrons to be on corresponding orbits of atom in stationary states. That's why Thomson -Rutherford improved atomic model can be used, and we propose the method of STationary Electrons (STEL) for atomic and molecule structures description [17 - 19]. This model provides very forming via the linkage of stationary electrons on outer atomic orbits. Such spatial molecular structures are fully according to widely accepted physics and chemistry conception. We present also calculation results for nucleus internal structure of deuterium, tritium and helium ^3He and ^4He.

2. Internal aerodynamics ofturbojet engine

United gas dynamic models, which takes place in flow paths of aircraft turbojet and turbofan engines, are presented. These models are relevant to high-class models based on real 3D geometry of engine flow path. They are also based on three-dimensional (3D), quasi-three-dimensional (two-dimensional (2D) with S_1 and S_2 planes) and one-dimensional (1D) approaches. The models can be applied either in isolated unit components or in entire engine flow passage. All approaches are closely connected among themselves. Together they form the dynamic system for efficiency analysis of entire engine flow path. This method of working process modeling considers all main features of engine working process (viscous losses, fuel addition and combustion, cooled air bleed and blow out, leakage from flow path, rotor and stator thermal dilatation, air humidity, rotor inertia and so on). Steady and transient modes of engine operation could be simulated via these models.

The unified mathematical model of the entire engine flow path is considered below (for detail, see [20 - 22]). The flow path includes air inlet, fan, bypass duct (if needed), compressor, main combustion chamber, high pressure and low pressure turbines, afterburner (if needed), and exhaust nozzle. The direct problem for specified flow path is being solved from the position of internal aerodynamics.

A turbojet bypass engine is sketchy shown on Fig. 1, where also there is emphasized multicomponent, multidimensional and multidiscipline of the considered problem.

The initial system of equations (Euler or Navier-Stokes) should be written in divergence form for the cylindrical coordinate system, which coincides with engine axis [20 - 22]. Rotor motion equations together with equations of chemical mixture state should be added to the initial system. Turbulence effects are described via two-parameter turbulence model [23].

For the convenience of numerical integration the initial system of equations can be written with the use of curvilinear coordinate system adapted to surfaces of flow path elements. The writing form of initial system of equations remains divergent. Equations can be integrated via CFD method based on the Godunov's scheme [24 - 26].

In this study we use the Godunov method with next peculiarities for any case (1D, 2D and 3D): finite volume formulations; conservative in adaptive grids; implicit; up to 3d order of accuracy; exact solution for arbitrary discontinuity break down (for Riemann problem); high resolution of shock waves and other discontinuities; entropy condition (the 2D law of thermodynamics) is explicitly includes into the numerical procedures (no expansion shocks).

Unified 2D models play an important role in the analysis of engine aerodynamics. These models can be obtained from the initial system of equations via radial or circumferential coordinate averaging (Fig. 2). The 2D problem definition on S_1 plane in variable thickness layer containing cascade can be obtained via radial coordinate averaging. The problem on S_2 plane is obtained via circumferential averaging [27]. Here the Godunov method with to an arbitrary discontinuity break down is very convenient.

Equations of transient 1D flows can be obtained from 3D equations via radial and circumferential averaging (or via radial averaging of S_2 plane equations). The method preserves a many features of S_2 approach: exact solution near inlet and outlet edges, transonic effects, compatibility with shock waves and so on [20 - 22].

One-dimensional methods are extensively used for preliminary optimization of flow path parameters (stage distribution of heat drops, the selection of reactivity ratio) under input limits. The 1D method is also used for performance calculation of engine or its subassemblies.

Below we present a lot of practical applications for turbojet flow path designing with the use of considered approaches. The results of such calculations practically coincide with experimental data and parameters of already realized engine projects.

3. Thermogasdynamic model of radiation component

The zero law of thermodynamics allows introducing a temperature as the state parameter. The temperature T_0 = 2.735K characterizes of cosmic background microwave radiation state.

Application the first and second laws for radiation (photon gas) gives the connection between increasing of entropyds, internal energy de and specific volume dv as

$$T\mathrm{d}s = \mathrm{d}e + p\mathrm{d}v$$

Remembering that

$$\mathrm{d}e = \frac{\partial e}{\partial T}\mathrm{d}T + \frac{\partial e}{\partial v}\mathrm{d}v$$

this equation can be written