INCAS – National Institute for Aerospace Research “Elie Carafoli”
(under the Aegis of the Romanian Academy)

Proceedings
of
the XXXVth “Caius Iacob” Conference
on
Fluid Mechanics and its Technical Applications

2013, November 14-15

Bucharest, Romania

Organizers

INCAS – National Institute for Aerospace Research “Elie Carafoli” (under the Aegis of the Romanian Academy)

ISMMA – Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy “Gheorghe Mihoc - Caius Iacob”

University of Bucharest

“Politehnica” University of Bucharest

BUCHAREST

2013

Proceedings of
the XXXVth "Caius Iacob" Conference on
FLUID MECHANICS and its TECHNICAL APPLICATIONS

2013, November 14-15, Bucharest, Romania

Sessions:

Aerodynamics Design; Numerical Analysis;
Microfluidics & nanofluidics; Mathematical Modelling

Publisher:	**INCAS – National Institute for Aerospace Research "Elie Carafoli"** B-dul Iuliu Maniu 220, 061126 Bucharest, Romania Phone: +4021 4340083; Fax: +4021 4340082 E-mail: incas@incas.ro; http://www.incas.ro

***Registration code**:*	**ISSN 2067-4414** **ISSN-L 2067-4414** **ISSN National Center** **Romanian National Library**

INCAS – National Institute for Aerospace Research “Elie Carafoli”
(under the Aegis of the Romanian Academy)

Proceedings
of
the XXXVth “Caius Iacob” Conference
on
Fluid Mechanics and its Technical Applications

2013, November 14-15

Bucharest, Romania

Organizers

INCAS – National Institute for Aerospace Research “Elie Carafoli” (under the Aegis of the Romanian Academy)

ISMMA – Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy “Gheorghe Mihoc - Caius Iacob”

University of Bucharest

“Politehnica” University of Bucharest

BUCHAREST

2013

Institutul Național de Cercetări Aerospațiale "Elie Carafoli"

INSTITUTUL DE STATISTICA MATEMATICA SI MATEMATICA APLICATA "GHEORGHE MIHOC-CAIUS IACOB"

UNIVERSITATEA DIN BUCUREȘTI

Universitatea Politehnica București

”Caius Iacob” Conference
of
Fluid Mechanics and its Technical Applications

14–15 November 2013, Bucharest

Programme

General Schedule

Thursday 14 November 2013

9.00-10.00	**Registration**
10.00-10.40	**Opening Ceremony, ”Elie Carafoli” Amphiteatre** *In Memoriam* Elie Carafoli
10.40-11.00	*Coffee Break*
11.00-12.40	**Lectures**
12.40-14.00	*Lunch*
14.00-16.00	**Lectures**
16.00-16.30	*Coffee Break*
16.30-18.30	**Lectures**
19.00-	*Banquet*

Friday 15 November 2013

09.30-10.00	**The “Nicolaie Tipei” Prize Award Ceremony**, ”Elie Carafoli” Amphiteatre
10.00-10.40	**Lectures**
10.40-11.00	*Coffee Break*
11.00-12.40	**Lectures**
12.40-14.00	*Lunch*
14.00-16.00	**Lectures**
16.00-	**Closing Ceremony**

Scientific Communications

Thursday 14 November 2013

		Aerodynamics Design
	"Elie Carafoli" Amphitheatre	
	Chairman: Dan Pantazopol, Cornel Oprişiu	
11.00-11.30	**Adriana Nastase**	*The Global Optimized Shapes of Flying Configurations Compared with Gliding Birds*
11.30-12.00	**Horia Dumitrescu, Vladimir Cardoş, Ion Mălăel, Al. Dumitrache**	*Small Vertical Axis Wind Turbines: aerodynamics and starting behavior*
12.00-12.20	**Cătălin Nae**	*Advanced Aerodynamic Technologies for Future Green Regional Aircraft*
12.20-12.40	**Marius Stoia-Djeska, Sterian Danaila, Carmen-Anca Safta**	*Aerodynamic Derivatives Calculation Using the Adjoint Method*

		Aerodynamics Design
	"Elie Carafoli" Amphitheatre	
	Chairman: Catalin Nae, Gelu Paşa	
14.00-14.20	**Sanda Budea, M.D. Cazacu**	*Velocity spectrum and blade's deformation of horizontal axis wind turbines*
14.20-14.40	**Al. Dumitrache, H. Dumitrescu, F. Frunzulică, V. Cardoş**	*Numerical Investigations on Aerodynamic Characteristics of H-Straight Vertical Axis Wind Turbine*
14.40-15.00	**Florin Frunzulică, Horia Dumitrescu and Alexandru Dumitrache**	*Numerical Investigations of Dynamic Stall Control*
15.00-15.20	**Valentin Adrian Jean Butoescu**	*Pitching and flapping wings laws for micro-air vehicles (MAV) in straight flight*
15.20-15.40	**Dragan Valeriu and Grad Danuta**	*An Iterative Method for Estimating Airfoil Deformation due to Solid Particle Erosion*
15.40-16.00	**Adrian Carabineanu**	*The flow of an incompressible electro-conductive fluid past a thin airfoil*

		Mathematical Modeling
"Elie Carafoli" Amphitheatre		
Chairman: Adrian Carabineanu, Horia Dumitrescu		
16.30-16.50	**Nicolae Marcov**	*About zeros of some oscillations with dynamic friction*
16.50-17.10	**Gelu Paşa**	*Saffman-Taylor problem with zero surface tension*
17.10-17.30	**Corneliu Berbente, Sorin Berbente**	*Analytical solutions for some problems of optimum with applications in air trafic and economics*
17.30-17.50	**George Savu**	*A Natural Turbulence Model For Boundary Layer*
17.50-18.10	**Ruxandra Stavre**	*The control of the pressure for a two fluids flow in a porous medium*
18.10-18.30	**Patrizia Donato, Iulian Ţenţea**	*Homogenization of an elastic double-porosity medium with imperfect interface via the periodic unfolding method*

Microfluids&Nanofluids

"Nicolae Tipei" Amphitheatre

Chairman: Marius Stoia

14.00-14.20	**J.B. Dumitru, A.M. Morega, M. Morega**	*An Electromagnetic, Flow, and Thermal Study of a Miniature Planar Spiral Transformer with Circular Windings*
14.20-14.40	**Nicoleta Tănase, Diana Broboană, Corneliu Bălan**	*CFD procedures implemented within the fluid mechanics teaching process*
14.40-15.00	**Ioana Omoncea, Rodica Damian, Catalin Mihai Balan**	*Experimental investigations of bi-phase flows in micro-channels*
15.00-15.20	**Dumitru Popescu, Iuliana Paşol**	*About Some Types of Pores Having an Important Rolle in Biological Structures Which Can Be Mathematically Modeled*
15.20-15.40	**Ştefan Săvulescu**	*Physical Aspects of the Theoretical* FLUONS *Model*

Numerical Analysis

"Nicolae Tipei" Amphitheatre

Chairman: Alexandru Morega, Corneliu Bălan

16.30-16.50	**Cecil P. Grunfeld and Dorin Marinescu**	*On a numerical approximation of the Boltzmann Equation with soft cut-off angular collision potential.*
16.50-17.10	**Stelian Ion**	*Water circulation in the soil-plant system. Errors analysis of a time integration method*
17.10-17.30	**Adrian Stoica**	*Numerical Solution For The Lifting Surface Integral Equation*
17.30-17.50	**Delia Teleaga, Marius Stoia-Djeska, Florin Frunzulică, Luiza Zavalan**	*A Comparison of the FVPM and FVM for Compressible Flows*
17.50-18.10	**Andreea-Irina Afloare and Achim Ioniţă**	*Prediction of the handling qualities and pilot-induced oscillation rating levels*
18.10-18.30	**Mihai Victor Pricop, Irina Carmen Andrei**	*Application of Newton-Busemann Flow Model to Earth Re-entry Capsules*

Friday 15 November 2013

		Aerodynamics Design
	"Elie Carafoli" Amphitheatre	
	Chairman: Ioan Ursu, Stelian Ion	
10.00-10.20	**Alexandru Catalin Macovei , Florin Frunzulica**	*Active flow control with synthetic jets for aerospace applications*
10.20-10.40	**Daniela Baran, Dorin Lozici-Brînzei and Simion Tătaru**	*Dynamic study of the virtual prototype of the IAR-99 SOIM Aircraft*
10.40-11.00	**Bogdan Vasile Moga**	*Theoretical study on compressive and bending behavior of nonmetalic honeycomb sandwich materials*

		Aerodynamics Design
	"Elie Carafoli" Amphitheatre	
	Chairman: Ioan Ursu, Stelian Ion	
11.20-11.40	**Tiberiu Adrian Salaoru, Dragoş Daniel, Ion Guţă, Marina Andrei, Minodor Arghir**	*Parameters monitoring and control for flueric actuators testing system*
11.40-12.00	**Ciprian Lupu, Mircea Lupu**	*Optimized solution for ratio control structures: Multiple propulsion systems case study*
12.00-12.20	**Ioan Sebeşan, Sorin Arsene**	*Study on aerodynamic resistance to electric rail vehicles generated by the power supply*
12.20-12.40	**Dan Vătui**	*The Utilitarian "Checker_DOC_W&B" for Control Documentation and the Creation the Gravimetry Database for an Aircraft Modeled in* CATIA V5

		Microfluids&Nanofluids
	"Elie Carafoli" Amphitheatre	
	Chairman: Ioan Ursu, Stelian Ion	
12.40-13.00	**Titus Petrila, Balazs Albert**	*Calculation of the Wall Shear Stress in the case of a Stenosed Internal Carotid Artery*

		Mathematical Modeling
	"Elie Carafoli" Amphitheatre	
	Chairman: Adrian Jean Butoescu	
14.00-14.20	**Andreea Iftene, Sorin Căluianu, Ilinca Năstase Ioan Ursu, George Tecuceanu, Adrian Toader**	*Synthesis and simulation of neuro-fuzzy HVAC systems*
14.20-14.40	**Marius Brebenel**	*Analysis of the chemical equilibrium of combustion at constant volume*
14.40-15.00	**Adrian Dobre**	*The structure of boundary layers over rough walls*

Contents

SECTION 1 – Aerodynamics Design
dedicated to the memory of Elie Carafoli

Global Optimized Shapes of Flying Configurations Compared with Those of Gliding Birds

Adriana NASTASE

Aerodynamics of Flight, RWTH, Aachen University, 52062 Aachen, Germany
nastase@lafaero.rwth-aachen.de

Abstract: *The determination of global optimized (GO) shape of a flying configuration (FC) (namely, the simultaneous optimization of its camber, twist and thickness distributions and also of the similarity parameters of its planform) leads to an enlarged variational problem with free boundaries. An own optimum-optimorum (OO) theory was developed in order to solve this enlarged variational problem. According to this OO theory, a lower limit hypersurface of the drag coefficients of elitary FCs versus the corresponding set of similarity parameters of their planforms is defined. The elitary FCs corresponding to the optimum set of similarity parameters, which is obtained by the numerical determination of the position of the minimum of this hypersurface is, at the same time, the GO FC of the set. The GO shapes of three FCs models were designed by the author according to her OO theory. The transversal cuts of the GO FCs look like those of gliding birds and also their behaviors, by changing of start values of optimization, are similar because nature optimizes too.*

Key Words: *Aerodynamical global shape optimization, Supersonic flow.*

1. INTRODUCTION

The determination of the shape of the surface of an elitary FC, with fixed planform, in order to have a minimum drag, at cruising Mach number and, additionally, to satisfy some chosen constraints, leads to a classical variational problem with fixed boundaries.

The determination of the GO shape of the surface and of the similarity parameters of its planform leads to an enlarged variational problem with free boundaries. The OO theory, developed by the author, is a strategy for the determination of the GO shape of FC inside of a class of elitary FCs defined by their chosen common properties. Two elitary FCs belong to the same class, if their surfaces are expressed in form of superpositions of polynomials with the same maximal degree, their planforms can be related through affine transformations and they fulfill the same constraints.

A lower-limit hypersurface of the inviscid drag functional $C_d^{(i)}$ as function of the similarity parameters ν_i of the planform is defined, namely:

$$\left(C_d^{(i)}\right)_{opt} = f(\nu_1, \nu_2, \dots \nu_n) \tag{1}$$

Each point of this hypersurface is obtained by solving a classical variational problem with given boundaries (i.e. a given set of similarity parameters). The position of the minimum of this hypersurface, which is numerically determined, gives us the best set of the similarity parameters and the FC's optimal shape, which corresponds to this set, is at the same time the global optimized FC's shape of the class. This OO theory was used by the author for the inviscid global optimization of the shapes of three models, with respect to minimum drag, at the cruising Mach numbers M_∞ = 2, 2.2, 3.0, respectively, it is: Adela (a delta wing alone) and two fully-integrated delta wing-fuselage FCs, Fadet I and Fadet II. The GO shapes of FCs look in transversal sections like gliding birds.

The changing of the GO shape due to changing one by one of the start values of the optimization, namely the cruising Mach number, of the lift and pitching moment coefficients is further analyzed and compared with behaviors of gliding birds.

2. DETERMINATION OF THE INVISCID GLOBAL OPTIMIZED SHAPE OF THE WING-FUSELAGE CONFIGURATION

The enlarged variational problem of the determination of the inviscid GO shape of the integrated wing-fuselage FC is now considered. It shall have a minimum inviscid drag, at cruising Mach number, M_∞. This FC is treated like an equivalent integrated delta wing, fitted with two artificial ridges, which are located

Velocity spectrum and blade's deformation of horizontal axis wind turbines

Sanda BUDEA, Mircea Dimitrie CAZACU

"POLITEHNICA" University of Bucharest, Faculty of Energetics,
Department of Hydraulics, Hydraulic Machinery and Environmental Protection
Spl. Independetei 313, Bucharest, 060402, Romania
sanda.budea@upb.ro, cazacu.dimitrie@yahoo.com

***Abstract**: The paper presents the velocity distribution calculated by numerical method in axial relative motion of a viscous and incompressible fluid into the impeller of a horizontal axis wind turbine. Simulations are made for different airflow speeds: 0.5,1, 3, 4, 5 m / s. The relative vortex on the backside of the blade to the trailing edge, and the vortices increase with the wind speed can be observed from the numerical analysis. Also the translational deformation-the deflection of the wind turbine blades for different values of the wind velocities has been established in this paper. The numerical simulations are made for the following speed values :5 m/s, 10m/s and 20 m/s. ANSYS CFD – Fluent was used both to calculate the velocities spectrum and to establish the translational blades deformations. The analyzed wind impeller has small dimensions, a diameter of 2 m and four profiled blades. For this small impeller the translational deformation increases with the wind velocity from 83 to 142 mm.. For high wind velocities and large–scale wind turbine impellers, these translational deformations are about several meters, reason to /shut-down the impellers to wind velocities exceeding 25 m/s.*

***Key Words:** axial velocity, wind turbine, blade deflection.*

1. INTRODUCTION

The wind turbines play an important role in the renewable energy field, reason to study their mechanical and aerodynamic behaviour, in order to improve theirs performances.

This article presents the results of the theoretical research in the study of aerodynamic behaviour of the impeller of a small wind turbine, having a diameter of 2 meters and four blades, by simulating different modes of operation, represented by different wind velocities. The aerodynamic modelling and design was made using ANSYS Code, in three dimensional coordinates. The first hypothesis of the theoretical analysis consisted in applying the geometric similarity. Thus, for the considered impeller with four blades, the analysis was made on a section of 90 degrees, containing the blades and the space between two consecutive blades. The spatial modeling assumptions and theoretical analysis hypothesis involved the translations and rotations (angular deformations)) blocked on all three directions at the impeller hub. The theoretical analyse of the aerodynamic behavior of the horizontal axis impeller took into account the airflow pressure and of the centrifugal forces of inertia in the case of three different wind velocities – 5, 10 and 20 m/s. The translational deformation increased with the wind velocity from 83 to 142 mm for this small impeller. For large-scale wind impeller these deformations can reach several meters, being generated both by the transport velocity *u* of the impeller and by the air pressure force. So, large impellers are blocked at high wind speeds equal to or exceeding 25m/ s. The aerodynamic profile was inspired from similar papers [1],[2],[3],[4],[5],[6]. The propeller geometry has the blade pitch angle to the hub of 10° and maximum blade specific twisting of 35°.

2. VELOCITY SPECTRUM

2.1 Modelling hypothesis

In numerical modelling, simplifying hypothesis were made, for example, it is considered that the wind acts directly (perpendicular) to the surface of the blade the velocities induced by the other neighbouring blades are neglected – the slipstream effect and geometrical similarity is applied. The effect of modifying the wind velocities is given by the blade loading with different pressures and different centrifugal forces of inertia. In similar papers [7],[8],[12] the wind turbine aerodynamics is analyzed by the CFD techniques. In order to obtain stable numerical solutions the wind speed v_0 (0,5 m/s, 1 m/s, 2 m/s, 4 m/s and 5 m/s) was kept constant and small Reynolds numbers were used initially. The lifting force given by the air over pressure and the centrifugal force was considered [9],[10]. The pressure on the lifting area is assumed to be perpedicular to each node of the meshed blade. The centrifugal force of inertia is applied at the blades extremity

Numerical Investigations of Dynamic Stall Control

Florin FRUNZULICA[1,2], Horia DUMITRESCU[2], Alexandru DUMITRACHE[2]

[1]"POLITEHNICA" University of Bucharest, Faculty of Aerospace Engineering
Polizu 1-6, RO-011061, Bucharest, Romania
ffrunzi@yahoo.com
[2]"Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy
Calea 13 Septembrie no. 13, 050711 Bucharest, Romania
horiadumitrescu@yahoo.com, alex_dumitrache@yahoo.com

Abstract: *In this paper we investigated numerically the dynamic stall phenomenon and the possibilities to control it, with application to vertical axis wind turbines (for urban users). The Phenomenon appear at low tip speed ratio (TSR<4) and it has a great impact on structural integrity of the wind turbine and power performances. For this reason we performed a computational study of dynamic stall around NACA 0012 airfoil in pitching motion at relative low Reynolds number (~10^5).*

Also, we performed the same analysis for four flow control methods: two passive (Gurney flap and slot) and two active (blowing jet on the rounded trailing edge and synthetic jet periodically activated). The Results are compared to those of an existing experimental case test.

Key Words: *vertical axis wind turbine, dynamic stall, flow control, RANS.*

1. INTRODUCTION

In the last years, for home users, the wind turbine with vertical axis (VAWT) has started to be more attractive due to its benefits in exploitation, the power range usually covering the domain ranging between 2 kW and 20 kW.

As compared to the widely used conventional Horizontal Axis Wind Turbines (HAWTs), VAWTs have many advantages, namely: they operate with wind blowing from any direction (thus simplifying the wind turbine system), they are designed for low wind speed, and operate at low/medium RPM, have lower vibration and small noise levels (being quieter in operation due to lower blade-tip speeds) and have lower manufacturing and maintenance costs [1].

But VAWTs also have many complicated aerodynamic issues, of which the dynamic stall is an inherent phenomenon at low values of the tip speed ratio (TSR < 4); it has a significant impact on vibration, noise, and power output of the VAWTs.

In terms of aerodynamics, when the wind speed approaches to the speed of operation (for a low value of the tip speed ratio) the blade airfoil of VAWT exceeds the critical angle of incidence for static conditions. The angle of incidence varies quickly across the blade which works in dynamic stall condition.

The effect of the dynamic stall is the lift increase with the rapid increase of the incidence and the lift decrease with the rapid decrease of the incidence, if compared with aerodynamic static characteristics (the dynamic stall delays both flow separation and flow reattachment).

These sudden variations of unsteady aerodynamic forces greatly enhance the unsteady loads on the blade and can be dangerous for the structural integrity of the blade [2].

The understanding of the fundamental aspects of the complex aerodynamics of VAWTs is crucial for a successful design of either small or large VAWTs, in particular at relatively low Reynolds number (Re ~ 10^5) appropriate to the urban/ suburban applications of VAWTs.

The present study focuses on investigating the dynamic stall characteristics and dynamic stall control of unsteady flow around the blades on a fixed pitch straight bladed VAWT (H-type) using computational fluid dynamics (CFD).

Due to the relative high aspect ratio of the VAWT blade, the simulation and analysis of the two dimensional (2D) modeling of VAWT blades give an efficient way to evaluate the blade profile performance away from the blade tips (median section of VAWT).

An Iterative Method for Estimating Airfoil Deformation due to Solid Particle Erosion

Valeriu DRĂGAN[1], Dănuţa GRAD[2]

[1]COMOTI – Romanian Gas Turbine Research and Development Institute
220 D Iuliu Maniu Avenue, 061126 Bucharest 6, Romania, P.O. 76, P.O.B. 174
drvaleriu@gmail.com
[2]"POLITEHNICA" University of Bucharest, Department of Aerospace Sciences
Splaiul Independenţei 313, 060042, Bucharest, Romania

Abstract: *Helicopter blades are currently constructed with composite materials enveloping honeycomb cores with only the leading and trailing edges made of metal alloys. In some cases, the erosive wear of the bound between the composite skin and metallic leading edge leads to full blade failure. It is therefore the goal of this paper to provide a method for simulating the way an airfoil is deformed through the erosion process. The method involves computational fluid dynamics simulations, scripts for automatic meshing and spreadsheet calculators for estimating the erosion and, ultimately, the airfoil deformation. Further work could include more complex meshing scripts allowing the use of similar methods for turbo-machineries.*

Key Words: *ICEM-CFD, scripting, erosion, k-omega SST, Wallace erosion model.*

1. INTRODUCTION

The erosion in the case of aerospace components is an important factor in the life cycle of any machine, particularly that of turbo machines. An example of helicopter blades failure due to erosion is presented in [1] while other references [2-5] study the deterioration of several types of turbine engine components due to the solid particle ingested.

This paper proposes a semi-automatic method that combines advanced CFD methods with advanced erosion models.

1. Standardization and facilitation of the meshing process.
2. Implementation of varies erosion models, independent of the CFD solver
3. Determination of the eroded airfoil geometry

- Because the meshing process is lengthy and generally the same steps.
- Fluent permits the selection of a certain basic class of erosion models. This means that more complex erosion models must make use of user defined functions which requires programming skills. Even with UDFs, the mathematical modeling of erosion is limited to a specific shape of equation Ref [6].

By outsourcing the erosion calculator, any type of mathematical erosion model can be used directly in its original form (without transformation). This permits the use of empirical or semi-empirical erosion models like the ones used for composite materials.

Because the mesh must envelope the existing airfoil surface, it is difficult to simulate real-time erosion processes in steady solvers.

On the other hand, unsteady simulations with adapting grids and deformable meshes consume more computational time and are difficult to implement. This problem is solved by the deformation by erosion calculator which uses a local offset function with a set magnitude (imposed at 0.01% of the chord) and the relative erosion rate calculated at the step before.

The eroded airfoil is then passed to the automatic pre-processors and the entire process is repeated. This insures that, throughout the computation, the mesh has the same parameters, limiting errors caused by the user's negligence. It must be said that the mesh generator only generates, links and attributes the geometry and blocking structure while meshing only the boundary layer. The user must decide whether the blocking remains the same or if adjustments are required. The meshing scripts are, therefore, just automated assistants and do not restrict the user's freedom.

The block splitting method also insures the connectivity of the blocking structure and, subsequently, the continuity of the final mesh.

Below, the flowchart of the entire process is presented.

The flow of an incompressible electroconductive fluid past a thin airfoil. The parabolic profile

Adrian CARABINEANU

University of Bucharest, Department of Mathematics
Str. Academiei 14, Bucharest Romania
"Caius Iacob – Gheorghe Mihoc" Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy
Calea 13 Septembrie 13, Bucharest, Romania
acara@fmi.unibuc.ro

***Abstract**: We study the two-dimensional steady flow of an ideal incompressible perfectly conducting fluid past an insulating thin parabolic airfoil. We consider the linearized Euler and Maxwell equations and Ohm's law. We use the integral representations for the velocity, magnetic induction and pressure and the boundary conditions to obtain an integral equation for the jump of the pressure across the airfoil. We give some graphic representations for the lift coefficient, velocity and magnetic induction.*

***Key Words:** linearized system, integral representations, parabolic airfoil.*

1. INTRODUCTION

The motion of a wing in an electoconductive fluid was investigated in the second half of the past century, when the researchers were interested in studying the aircraft flow in special meteorogical conditions or at high altitude in an ionized athmosphere. In the papers dedicated to this subject, the lift, drag and moment coefficients were calculated. Recent technological advances claim also for the study of the velocity and electromagnetic fields. We mention two examples: the plasma actuators for aircraft flow control (see [3]) and concealing aircrafts from radar using the interaction between the ionized gas and the electromagnetic radiation. In the present paper we study the steady two-dimensional flow of an ideal perfectly conducting incompressible fluid around a thin insulating parabolic airfoil. We consider the linearized partial differential equations of magnetohydrodynamics consisting of Euler's and Maxwell's equations and Ohm's law.

In [2] we calculated the corresponding fundamental matrix and obtained integral representations of the velocity, the magnetic induction and the pressure fields for arbitrary thin airfoils. We notice that every integral representation has an elliptic as well as a hyperbolic part, the last one being determined by the presence of simple waves bounded by straight characteristics (weak shocks). From the integral representation of the velocity and the boundary conditions (linearized slipping condition and the continuity of the magnetic induction) we rediscover the singular integral equation for the jump of the pressure across the airfoil (see [2],[4], [6], [7]).

We consider the particular case of the parabolic profile for which the solution of the integral equation is analitically calculated. Then we calculate the lift coefficient and perform some numerical integrations to calculate the velocity and the magnetic induction in the points of a two-dimensional grid. We provide graphic representations for the velocity and magnetic induction fields and for the lift coefficient.

2. FUNDAMENTAL MATRIX OF THE LINEARIZED SYSTEM FOR THE TWO-DIMENSIONAL INCOMPRESSIBLE FLOW OF PERFECTLY CONDUCTING FLUIDS

The results presented in Sections 2-4 were obtained in [2]. We assume that the plane-parallel motion occurs in the Oxy plane and we denote by **i** and **j** the versors of the Ox and Oy axes. Let **v**,**b** and p designate the nondimensional perturbations of the velocity, magnetic induction and pressure, respectively, determined by the presence of a thin insulating airfoil whose equation is

$$y = h_{\pm}(x),\ x \in [0,1],\ |h_{\pm}(x)| << 1,\ |h'_{\pm}(x)| << 1. \tag{1}$$

At infinity upstream, we assume that the unperturbed motion is uniform and parallel to the Ox - axis and that there exists a homogeneous magnetic field whose nondimensional expression is

Numerical simulations of synthetic jets in aerodynamic applications

Alexandru Catalin MACOVEI[1], Florin FRUNZULICA[2]

[1]Fokker Engineering Romania
Sos. Pipera 1/VII Nord City Tower, Voluntari, Ilfov, Romania
alexandru_macovei@yahoo.ro;
[2]"POLITEHNICA" University of Bucharest, Faculty of Aerospace Engineering
Polizu 1-6, RO-011061, Bucharest, Romania
ffrunzi@yahoo.com.

Abstract: *This paper presents numerical simulations of synthetic jets in aerodynamic applications. We've analyzed the formation of isolated synthetic jets, the influence of nozzle geometry and the interaction of synthetic jets with a uniform flow on a flat plate. Also we've studied the influence of the active control in interaction with a stalled airfoil and the controllability of dynamic stall phenomenon. The results are obtained using a dedicated CFD solver. Appropriate comparisons are made with results from scientific literature; as well the numerical results are compared with a set of experimental images.*

Key Words: *synthetic jet, actuator, flow control, active control, dynamic stall, boundary layer*

I. INTRODUCTION

A relatively new device for controlling the flow, produced and tested in the laboratory, is known as "synthetic jet actuator". Synthetic jets are produced by a sound source which is at the base of a cavity communicating with the surface exposed to the flow through the circular orifice, as seen in Figure 1.

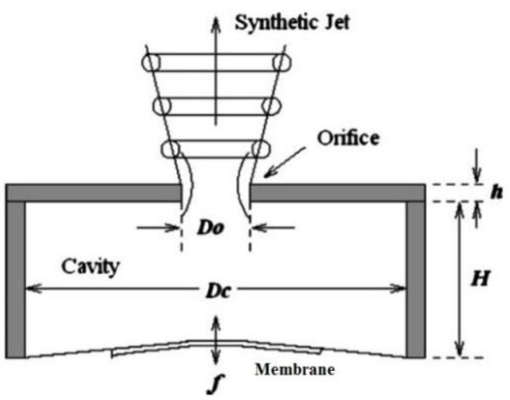

Figure 1. The conceptual scheme of synthetic jet actuator [3]

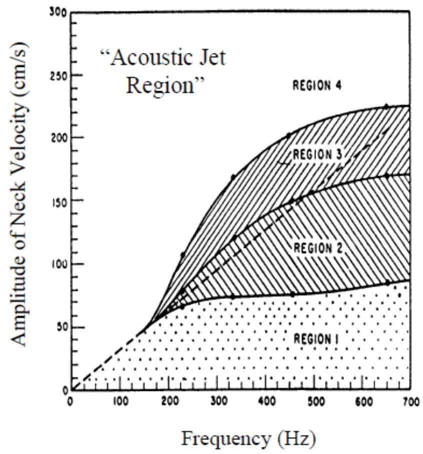

Figure 2. Zoning of acoustic jets [3]

The actuator is composed of a rigid-walled chamber, an inlet in the upper part exposed to the exterior flow and an elastic membrane which is opposite the orifice. In the phase in which the membrane moves down ward, the outside fluid is drawn into the cavity through the opening. When the membrane moves up, the fluid is discharged through the opening back to the outside flow. If the jet has sufficient energy a vortex ring is generated.

When the cycle is repeated periodically, a vortices column is generated. Sintered synthetic jet adds momentum to the fluid from the outside flow, this happens without added flux mass. Therefore synthetic jets are preferred at the expense of conventional jets.

At a high level of excitation of the elastic membrane, represented by the maximum amplitude of the membrane displacement, it is observed the emanation of a regular fluid jet.

Because there is no additional contribution of mass, the stream lines should form a closed circulation as shown in Figure 1.

This phenomenon of acoustic jet stream through an orifice which is based on a highly excited acoustic diaphragm is well known for many years. Figure 2, [3], shows the four regimes of circulation and turbulence

Dynamic study of the virtual prototype of the IAR-99 SOIM Aircraft

Daniela BARAN[1], Dorin LOZICI-BRINZEI[1], Simion TATARU[2]

[1]INCAS – National Institute for Aerospace Research "Elie Carafoli"
dbaran@incas.ro, lozicid@incas.ro
[2]Aerospace Consulting
B-dul Iuliu Maniu 220, Bucharest 061126, Romania
sitataru@incas.ro

***Abstract**: This paper contains a dynamic study of the IAR-99 SOIM aircraft using ADAMS, multibody dynamic solutions. First, the analysis of the whole airplane is envisaged and then the analysis of the flight control system and the landing gear are considered. The study is performed in the idea of upgrading the IAR-99 aircraft being a continuation of a previous study concerning a flutter analysis [9] of the same aircraft, and will be followed by a paper dedicated to modern tools in the stress analysis of the aeronautical structures. Using ADAMS one can build and test complex virtual prototypes, simulating mechanical systems in a realistic manner, both visually and mathematically which is very useful before developing a real prototype. Engineers can study the dynamics of moving parts and how loads and forces are distributed throughout a complex mechanical system as an airplane. In this way multiple design solutions can be analyzed and evaluated in order to shorten the time and to reduce the cost of a new project.*

***Key Words:** virtual prototype, numeric simulation, landing gear, flight control system.*

1. INTRODUCTION

Creating and analyzing virtual prototypes is a discipline based on the extraordinary development of the computing abilities. A specialized tool for creating and analyzing complex mechanical systems (as for example an airplane) is ADAMS, multibody dynamic solutions, which can be used to model, simulate, visualize 3D mechanical systems in real functioning conditions facilitating to define and optimize different projects using iterative design technique. Many CAD specialized softs are compatible with ADAMS, so the analysis performed in ADAMS can be transferred in other programs (ANSYS, NASTRAN, etc.). Building a virtual prototype should consider some aspects described in the following lines.

The solution of the virtual prototype has to be *integrated*, which means that working team must use a familiar CAD system for all the team members in order to have a simple transfer between the different design groups (mainly to the FEA groups). The solution has to be *adaptable*, in order to be able to use standard simple models in order to let less trained members of the research team to test different cases in order to optimize the considered structure. Also the solution has to be *parametric,* to permit quick changes in the whole model, to offer a good visualization of the project so that the analyzing team to be able to decide how to surpass the "sensible" points of the project. These features are decisive for those who analyze the virtual prototype and, in the same time for those who will build the physical prototype as well. In this paper we perform a dynamic study of the IAR-99 using ADAMS for the whole aircraft, for the flight control system and for the landing gear.

2. DYNAMIC RESPONSE OF THE VIRTUAL PROTOTYPE OF THE IAR-99 SOIM AIRCRAFT

2.1 General formulation

Usually, a dynamic analysis requires the following steps:

1. Prepare the model. The analyst should:
   a. discretize the structure by choosing the points in which we want to obtain the dynamic response,
   b. Prescribe how the structure is loaded,
   c. Prescribe how the structure is supported.
2. Perform the calculations.
   a. generate the stiffness matrix k and the mass matrix m of the different parts of the considered assemble,

Optimized solution for ratio control structures: Multiple propulsion systems case study

Ciprian LUPU[1], Mircea LUPU[2]

[1] "POLITEHNICA" University of Bucharest, Faculty of Automatics and Computer Science
313, Splaiul Independentei, Sector 6, Bucharest 060042, Romania
ciprian.lupu@acse.pub.ro
[2]Transilvania University of Brasov,
B-dul Eroilor nr. 29, 500036 Brasov, Romania
emlupu2006@yahoo.com

Abstract: *Modern aero-naval traction systems contain two or more propulsion elements. One of the main challenges consist steering control in case one or more propulsion elements fails. The paper presents solution of real time (re)balancing a parallel control structure and maintaining the ratio between two engines groups. Applicability is proved on a control structure of the ratio where using two groups of propellers, a situation encountered to the modern ships.*

Key Words: *ratio control, optimization, control structures, multiple propulsion.*

1. INTRODUCTION

The high demand for aero-naval superior speed, maneuverability, safety etc. performances required implementing of multiple propulsion systems (Fig. 1). The main advantages of these solutions are well-known: reduced volume and maintenance, increased maneuverability and modularity. In the same time, as other included important element/substructure damage [1-5], one of the main problems of multiple propulsion systems is optimal reconfiguration in case of failure or limitation of one propeller.

Steering is one of most affected parameters and imposes special solutions [6-7]. In some cases, especially for symmetrical structure, ratio control on traction subsystem could be an interesting solution. Proposed solution may be significance for modern structures as UAV type in which the elements of type ailerons, vertical or horizontal empennage are reduced or no longer exists [8-10].

In general terms, the ratio control between two or more quantities was and continues to be an important subject in the area of practical applications.

With time, various solutions, from simple ones like series or parallel (Figure 2) ordering of control loops to solutions using adaptive systems and structures, have been proposed and implemented. A very short list of works from this area can include [11-14].

In case of propeller/traction failure, general practice requires symmetrical engine stop or compensate it by other existing elements (tail etc.). Clearly, this is not the most efficient in terms of speed, fuel consumption, etc.

The paper tries to offer some solutions in which the ratio itself must be modified during the steering operation (real time).

The operation has functional domain limitation and must be developed as fast as possible and with assuring the highest precision of keeping it in the transitory phase that follows the adjustment.

Fig. 1 Multiple engine airplane examples

Study on aerodynamic resistance to electric rail vehicles generated by the power supply

Ioan SEBESAN, Sorin ARSENE

"POLITEHNICA" University of Bucharest, Transport Faculty,
Depart Rolling Stock Railway
Splaiul Independentei no. 313, Sector 6, Code 060042, Bucharest, Romania
ioan_sebesan@yahoo.com, sorinarsene@gmail.com*

Abstract: *Improving the traction performance of the electric railway vehicles requires an analysis to reduce their aerodynamic resistance. These vehicles cannot be set in motion without an external power source, which demonstrates that the supply system is a key-element to their operation. The power source is located on the rooftop which basically results in an increase of their aerodynamic resistance. The present study discusses the aerodynamic resistance of the electric railway equipment such as pantographs, automatic circuit breaker, insulators, etc. The analyze is based on the equipment installed on the electric locomotive LE 060 EA of 5100 kW which is operational in Romania, emphasizing the pantographs role in capturing of electricity.*

Key Words: *aerodynamic resistance, electric rail vehicles, electric locomotive, drag coefficient, electric railway, pantograph*

1. INTRODUCTION

The general formula of drag for the railway vehicles, known as Davis relation [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11] is given by:

$$R_t = a + b \cdot v + c \cdot v^2, \tag{1}$$

where

R_t – total drag of the train;
a – mechanical rolling resistances caused by the axle loads;
$b \cdot v$ – Nonaerodynamic drag;
$c \cdot v^2$ –Aerodynamic drag ;
v – speed of the vehicle;

In the literature of specialty [12], [13], [14], [15], [16], [17], [18], the explanation of the "*c*" parameter is given by:

$$c = \frac{C_x \cdot S \cdot \rho}{2}, \tag{2}$$

where

$C_x = \dfrac{2 \cdot F_x}{S \cdot \rho \cdot \bar{v}^2}$ – aerodynamic coefficient of air sliding (also known as the coefficient of air penetration) (dimensionless);

S – front surface of the vehicle in cross section (m2);
ρ – density of the moving vehicle air (kg/m3);
F_x – the frontal sliding force (N);
$\bar{v}$ – velocity of the fluid (air) (m/s).

In the article „Aerodynamics of high-speed railway train" [1] the authors state that in a series of tests made in a "test tunnel" on TGV trains at a speed of 260 km/h they found that "Of the total aerodynamic drag, about 80% is given only by the body train aerodynamics, 17% of aerodynamics is due to the pantograph system and other devices on the train and the remaining 3% is caused by the braking mechanisms, etc."

In the same article, another study on ICE trains showed that "depending on the cross section shape of the motor vehicle, on its roof equipment, and on that located between the chassis and the running plane and also

SECTION 2 – Numerical Analysis

A Numerical Solution for the Lifting Surface Integral Equation

Adrian STOICA

Faculty of Physics, University of Bucharest
Str. Atomistilor nr 405, P.O. Box Mg-11, Bucharest-Magurele, Romania
adst21@yahoo.com

Abstract: *In this paper, we present a new numerical treatment of the lifting surface integral equation (LSIE) in the case of rectangular wing planform. The kernel of this equation possesses a strong singularity in Hadamard sense. First the equation is transformed into one containing weaker singularities, of Cauchy-type, and then the 2D singular integral is discretized by the aid of the Gauss-type quadrature formulae. Thus the problem is reduced to a finite system of linear algebraic equations. The numerical simulation reveals a very good agreement, in terms of jump pressure over the wing and aerodynamic coefficients, with the exact solution in the case of the low aspect ratio wing and also with other numerical solutions.*

Key Words: *Gauss type quadrature, singular integral equation, rectangular wing planform*

1. INTRODUCTION

In the Multhopp's paper [7] we are led to the lifting surface integral equation (LSIE) in subsonic flow for the unknown dimensionless jump pressure over a wing which is supposed to be infinitely thin:

$$-\frac{1}{4\pi}\overset{*}{\iint_D}\frac{f(\xi,\eta)}{(y-\eta)^2}\left(1+\frac{x-\xi}{\sqrt{(x-\xi)^2+\beta^2(y-\eta)^2}}\right)d\xi d\eta = h_x{}'(x,y),\ (x,y)\in \overset{\circ}{D} \tag{1}$$

where D is the wing planform namely projection of the wing on XOY plane, $f(x,y)=p(x,y,+0)-p(x,y,-0)$ is unknown, $\beta=\sqrt{1-M_\infty^2}$ is the compressibility coefficient, M_∞^2 is the Mach number of the undisturbed flow and $z=h(x,y)$ is the equation of the mean surface of the wing such that $|h_x'| << 1$. In the case of the flat plate at uniform angle of attack $\varepsilon << 1$, $h(x,y)=-\varepsilon x$. The leading and trailing edges of the wing planform are described by the equations $x=x_-(y)$ and $x=x_+(y)$ respectively. The wing's geometry is shown in the Figure 1 below.

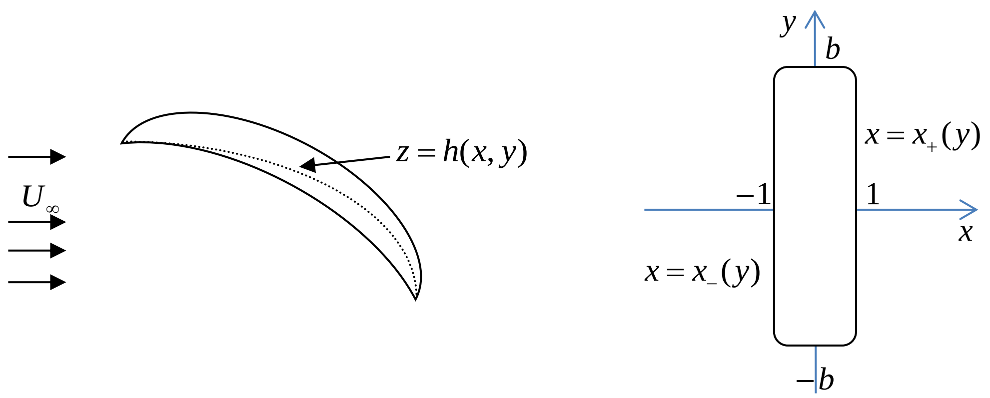

Fig.1 The wing's geometry

The integral contains a strong singularity at $\eta = y$, the asterisk standing for "Finite Part" integral in Hadamard sense defined by

$$\overset{*}{\int_{-b}^{b}}\frac{g(x,y,\eta)}{(y-\eta)^2}d\eta = \lim_{\varepsilon\to 0_+}\left(\int_{-b}^{y-\varepsilon}+\int_{y+\varepsilon}^{b}\frac{g(x,y,\eta)}{(y-\eta)^2}d\eta - 2\frac{g(x,y,y)}{\varepsilon}\right) \tag{2}$$

Prediction of the handling qualities and pilot-induced oscillation rating levels

Andreea-Irina AFLOARE[1], Achim IONITA[1]

[1]STRAERO – Institute for Theoretical and Experimental Analysis of Aeronautical Structures
B-dul Iuliu Maniu 220, Bucharest 061126, Romania
afloare.andreea@straero.ro, achim.ionita@straero.ro

Abstract: *The basis for the aviation development is the ambition of increasing the efficiency and safety of flight. Improvements include flight performance and extended flight envelope, new flight regimes and tasks. However, all of these factors lead to the increase of pilot workload which can reduce the accuracy and safety of flight. Fixed and rotary wing pilots are being confronted with potential instabilities or with annoying limit cycle oscillations, known as Aircraft/Rotorcraft Pilot Couplings (A/RPC) that arise from the effort of controlling the vehicle with high response actuators.*

This paper deals with the unified theory of predicting handling qualities level (HQSF) and pilot-induced oscillation rating levels (PIOR) based on the structural model of human operator, developed by Hess. HQSF and PIOR are capable of capturing the prominent features of human pilot dynamics characteristics for a large class of aerial vehicles and tasks. The key element in this method is to unify the topics of vehicle handling qualities and RPC/PIO, applied to the analysis of a medium weight helicopter model.

Key Words: *flight performance, extended flight envelope, aircraft/rotorcraft pilot couplings, handling qualities level, pilot-induced oscillation rating level*

LIST OF ABBREVIATION

APC – Aircraft Pilot Coupling
A/RPC – Aircraft/Rotorcraft Pilot Coupling
ARISTOTEL – Aircraft and Rotorcraft Pilot Couplings – Tools and Techniques for Alleviation and Detection
ASE – Aero-Servo-Elastic
AFCS – Automatic Flight Control System
HQ – Handling Qualities
HQSF – Handling Qualities Sensitivity Function
PIO – Pilot Induced Oscillation
PIOR – Pilot Induced Oscillation Rating
PSD – Power Spectral Density
RB – Rigid Body
RPC – Rotorcraft Pilot Coupling
SPM – Structural Pilot Model
u_m – proprioceptive feedback signal
c(t) – time evolution
τ_e – time delay
$Y_c(s)$ – transfer function of rotorcraft
$Y_p(s)$ – transfer function of pilot
ω_c – crossover frequency

1. INTRODUCTION

An adverse aircraft-pilot coupling (APC) or pilot-induced oscillation (PIO) can be defined as an unwanted, inadvertent, and a typical closed-loop coupling between a pilot and the response variables of an aircraft [1]. APC or PIO problems are not new phenomena; indeed, they have been around since the Wright Brothers and have been referred to as the senior handling qualities problem [2]. McRuer gives a concise historical perspective of the PIO problem, including a review and discussion of pilot behavior patterns. Because of a strong correlation between APC/PIO susceptibility and full-authority control systems employing fly-by-wire

Application of Modified Newton Flow Model to Earth Reentry Capsules

Mihai Victor PRICOP[1], Irina Carmen ANDREI[1], Mircea BOŞCOIANU[2]

[1]INCAS – National Institute for Aerospace Research "Elie Carafoli"
Flow Physics Department, Numerical Simulation Unit
B-dul Iuliu Maniu 220, Bucharest 061126, Romania
vpricop@incas.ro, andrei.irina@incas.ro
[2]Transilvania University of Brașov,
Faculty of Technological Engineering and Industrial Management
Str. Politehnicii nr. 1, Brașov 500024, Romania
boscoianu_mircea@yahoo.co.uk

Abstract: *This paper presents an implementation of the modified Newton method for the aerodynamic analysis of Planetary Reentry Capsules. A straightforward method is employed, such that a CATIA model and its hybrid surface mesh are used as input. Reference capsules are analyzed and results are compared to other similar codes. Future improvements of the code consider the Busemann correction of the wall pressure, heat flux evaluation and unsteadiness in order to enable the analysis of the hypersonic portion of trajectory and to assess the vehicle's stability.*

Key Words: *Planetary Reentry Capsule, Modified Newton model, aerodynamic analysis, trajectory analysis.*

1. INTRODUCTION

The reentry capsules have been developed since there is a continuous expansion of the mankind towards the extreme frontiers of the Universe, and hence, this increased the demand for appropriate technical equipment and device. Reentry capsule configurations significantly differ from each other due to entry conditions, trajectory, and a number of aerodynamic factors such as aerodynamic axial force, normal force, static moment, damping coefficients.

The flow-field over the reentry capsule becomes further complicated due to the presence of corner at the shoulder and the base shell of the reentry module. A high-speed flow-past a reentry capsule generates a bow shock wave which causes a rather high surface pressure and as a result the development of high aerodynamic drag which is required for aero-braking purposes.

Highly blunt configurations are generally preferred to decelerate the space-capsule for safe returning on the Earth after performing the experiments. The bow shock wave is detached from the blunt fore-body and has a mixed subsonic supersonic region between them.

The wall pressure distribution, the location of the sonic line and shock stand-off distance on the spherical cap region have been analytically calculated at very high speeds with an adiabatic index near to unity which gives a singular point at 60 deg from the stagnation point (Chester 1956; Freeman 1956), Van Dyke [16]. The analytical approach for the high-speed flow over the blunt-body is considerably difficult and complex (Lighthill 1957), [17].

The work confirms that high-temperature transport phenomena markedly influence the vehicle flowfield and, in turn, the vehicle aerodynamics and aerothermodynamics, but it also stresses that, with an acceptable loss of results accuracy, there is not necessary to use models of such high complexity, and therefore considerable computing time can be saved. Safe landing of vehicles re-entering from space requires an accurate understanding of all physical phenomena that take place in the flowfield past the hypersonic vehicle to assess its aerodynamics and aerothermodynamics performance.

Real gas effects have strongly influence on both aerodynamics and aero-thermal loads of hypervelocity vehicles, as shown by flight measurements collected during reentry. The trajectory calculation for atmospheric reentry involves determining the vehicle aerodynamics and aerothermodynamics.

As a consequence, the accurate modeling of flow physics, in particular the flow chemistry is fundamental to reliably design reentry vehicles. On the other hand, high accuracy in modeling flow and

SECTION 3 – Microfluidics & Nanofluidics

Electromagnetic, flow and thermal study of a miniature planar spiral transformer with planar, spiral windings

J. B. DUMITRU[1], A. M. MOREGA[1,2] and M. MOREGA[1]

[1] "POLITEHNICA" University of Bucharest, Faculty of Electrical Engineering
313 Splaiul Independentei, 060042, Bucharest, Romania
dumitrujeanbogdan@yahoo.com, mihaela@iem.pub.ro
[2]"Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy, Calea 13 Septembrie no. 13, 050711 Bucharest, Romania
amm@iem.pub.ro

Abstract: *This paper presents mathematical modeling and numerical simulation results for a miniature, planar, spiral transformer (MPST) fabricated in micro-electromechanical MEMS technology. When the MPST is magnetic nanofluid cored, magnetization body forces occur, entraining it into a complex flow. This particular MPST design is then compared with other competing solutions concerning the lumped (circuit) parameters. Finally, the heat transfer problem is solved for different electromagnetic working conditions to assess the thermal loads inside the MPST.*

Key Words: *power transformer, fluid core, magnetic nanofluid, flow, magnetic field, lumped parameters, heat transfer, numerical simulation, finite element.*

1. INTRODUCTION

Recent advances in the development of micro-power microcontrollers and RF transmitters have led to a growing interest in new wireless devices that use *energy harvesting sources* (EHS)—as an alternative to batteries—aimed to scavenge small amounts of energy from artificial light, vibrations, temperature gradients, *etc*. and to convert it to useful electrical energy [1-5].

A key component of an EHS is the fly-back transformer (called also "coupled inductors"), which has to meet certain specifications: small size, low profile, thermal stability, high efficiency, and low cost. A *Miniature Planar Spiral Transformer* (MPST) with circular windings developed in *micro-electromechanical systems* (MEMS) may be an alternative to coupled inductors [6].

Usually, the magnetic core of an MPST is made of ferrite. However, recent studies showed that magnetic nanofluids consisting of tiny magnetized iron oxide nanoparticles (magnetite) dispersed in an oil suspension are a sound candidate [6-9] to replace the ferrite.

Such magnetic nanofluids, which are becoming a common solution in power transformers as cooling and insulating medium [7-10], also overcome the problem of iron losses in the transformer, especially at high frequencies, due to their near-zero hysteresis, thus enhancing the overall performance of the device.

2. AN MPST POWER TRANSFORMER

An MPST power transformer consists of two circular copper coils built on a ceramic substrate (Al_2O_3). The MEMS technology permits the growth of copper windings with cross-section areas as low as 50×50 μm^2 and even lower.

In the particular design of concern in this study the case and central column of the transformer, which are parts of the magnetic core, are made of 3F3 ferrite. The gap between the windings is filled with magnetic nanofluid [10-13].

If the magnetic field end effects of the windings are neglected, axial symmetry may be assumed for the MPST, which results in a reduced computational effort since the numerical problem may be reduced to a 2D model.

Fig. 1 presents a schematic view of this notional MPST with planar windings, and the 2D axial-symmetric computational domain used throughout the numerical simulations.

About some types of pores havind an important rolle in biological structures which may be mathematically modeled

Dumitru POPESCU[1,2], Iuliana PASOL[2]

[1] "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy, Department of Mathematical Modelling in Life Sciences
Calea 13 Septembrie no. 13, 050711 Bucharest, Romania
popescu1947@yahoo.com
[2]University of Bucharest, Faculty of Biology, Department of Physiology and Biophysics
Splaiul Independenţei 91-95 Sector 5, 076201 Bucharest, Romania
pasoliuliana@yahoo.com

***Abstract**: In this paper we will present some pores types which are met in some important biological structures. Some of them are studying, but other will be taken in study in the next time. We have divided them in two groups. In the first group it were included transmembrane pores. These pores are in cellular membranes and lipid bilayers. They have cylindrical formed. In the pulsatory liposome the transient pores have an essential role in their running. In the second group we are included the pores which exist in bones. These pores have an irregular form. Beside their importance in the own internal processes of bones, we will take them into account in the theoretical study of the piezoelectricity properties of the human long bones.*

***Key Words:** endothelial pores; transient pores; bone porozity*

1. INTRODUCTION

There have been a tremendous number of theoretical and experimental studies on the appearance, existence and stability of pores through lipid membranes [4, 7, 9]. The pores are an essential way to transport biochemical substances and/or biological material in, or through some biostructures from a being.

Some pores are genetically formed, other appears in certain conditions. Some of them are static, other have a dynamic evolution. Some are as small so that may be liked as a structural defects, but other has macroscopically dimensions.

So we can say the alive organism is very complex and very heterogeneously body. Having these ideas in mind, this paper si organized as follows. After a short introduction, comes next the section 2 which presents the first type of genetically pores, that is endothelial pores.

Another genetically pores are presented in the section 3. Section 4 analyzes the type of dynamical pores which appears in pulsatory liposomes. Finally, section 5 outlines the main conclusions.

2. GENETICAL PORES

An interesting case of genetical pores was found in the wall of sinusoidal vessels from the mammalian liver. The sinusoids represent the main microcirculatory component of the liver. The endothelial cells of the liver sinusoidal wall have numerous sieve plates with diaphragmless pores.

These pores of about 0.1 μm diameter, were named endothelial pores (sometimes called fenestrae) and control the exchange of fluids, solutes and particles between the sinusoidal blood and space of Disse.

With other words, the endothelial pores constitute an open connection between the sinusoidal lumen and the space of Disse bordered on the opposed part by the hepatic cells surface (named parenchymal cell surface) [14].

2.1 ENDOTHELIAL PORES

So, the endothelial pores found in sinusoidal wall are arranged in clustered domain that were defined as "sieve plates". The diameter of pores follows a Gaussian distribution. On the other hand, unlike the vessels in the peripheral circuit, the sinusoid diameter increases down the duct, that is this has a smaller diameter near the portal vein than near the central vein.

This inversion drew my attention. A direct consequence of this fact would be a decreases in blood velocity along the sinusoid. Therefore, the largest value of the blood velocity is located at the portal vein.

Correlations between the theoretical Fluons model and the physical experimental results

Stefan N. SAVULESCU[1], Florin BALTARETU[2]

[1]INCAS – National Institute for Aerospace Research "Elie Carafoli"
B-dul Iuliu Maniu 220, Bucharest 061126, Romania
[2]Technical University of Civil Engineering Bucharest,
Department of Thermal Engineering,
Bd. Pache Protopopescu nr. 66, 021414, Bucharest, Romania
flbaltaretu@yahoo.com, florin.baltaretu@instal.utcb.ro

Abstract: *This paper continues the recent research of the authors concerning the Fluons mathematical model, as a theoretical basis for the interaction between the micro and macro flow structure domains (further on called IPmMD). Correlations with physical experimental results are pointed out, by revealing some traces of the IPmMD and its influence to the field of fluctuations.*

Key Words: *integro-differential formulation, Fluons model, turbulence.*

1. INTRODUCTION

In our previous paper [1] we presented the mathematical aspects concerning the Fluons concept. The present paper analyzes the physical experimental support of this mathematical model. Essentially we discuss the connection between the Fluons model and the field of fluctuations associated to the mean velocity distributions in boundary-layer, channel and pipe flows.

This analysis stands for another point of view, which does not need to start with the empirical decomposition:

$$\vec{V} = \underbrace{\left(\overline{\vec{V}}\right)}_{mean} + \underbrace{\left(\vec{V}'\right)}_{fluctuation} \tag{1}$$

in order to appreciate the flow as laminar, transitional or turbulent.

We try to point out the existence of a physical process concerning the interaction between the micro and macro flow structure domains (further on called IPmMD), revealed experimentally as a fluctuation field. As a theoretical basis for the IPmMD we propose the Fluons model [2]. Some qualitative results concerning the global intensity and the distributions form of the fluctuations associated to a given velocity distribution raises the necessity to investigate qualitatively and quantitatively the field of wall layers flow fluctuations revealed by experiments. Accordingly, we will take into consideration the physical principles of mass conservation, increasing entropy generation and equipartition of the kinetic energy at the various time-space scales, required by IPmMD. The Fluons model allows explaining the physical existence of some finite domain of fluctuation (like the turbulent spot), the tendency towards the minimum of the global energy in some macroscopic domains, as well as the connection between micro and macro scales by successive transformations.

The successive transformations attain the scale of the molecular chaos, i.e. the discrete structure of the fluids, by using physically the same integral algorithm. Let's consider a given distribution $f = f(\eta)$, with $0 \le f(\eta) \le f_e = f(1)$, $0 \le \eta \le 1$ which provides the inversion $\eta = \eta(f)$ (analytically or numerically). By using the transformation:

$$\eta_2(\eta) = \frac{\int_0^\eta f^2(\eta)\mathrm{d}\eta}{\int_0^1 f^2(\eta)\mathrm{d}\eta} \tag{2}$$

and by writing $\eta_2 \to \eta$ and $f(\eta) \to f^*(\eta)$, we get the distribution $f^*(\eta)$, with $0 \le f^*(\eta) \le 1$, for $0 \le \eta \le 1$. Also, by using the transformation:

Calculation of the Wall Shear Stress in the case of an Internal Carotid Artery with stenoses of different sizes

Titus PETRILA[1], Balazs ALBERT[2]

[1]"Vasile Goldis" Western University, No. 94 Bd. Revolutiei, 310025 Arad, Romania
Member (Assoc.) of Academy of Romanian Scientists,
No. 54 Splaiul Independentei, 050094 Bucharest, Romania
aosrtransilvania@yahoo.com
[2]"Babes - Bolyai" University
No. 1 Mihail Kogalniceanu, 400084, Cluj-Napoca, Romania
balazsalb@gmail.com

***Abstract**: In this paper we use a non-Newtonian mathematical model for the blood flow in large vessels – elaborated and presented already by us in a previous paper [1]. We calculate and than compare the values of the wall shear stress, which has a special importance in the possible ruptures of vascular vessels (in the case of a human internal carotid artery with stenosis) in four different cases. The numerical simulations are made using COMSOL Multiphysics 3.3, and the results are compared to some already existing in the literature.*

***Key words**: blood flow; non-Newtonian model; stenosed artery; wall shear stress; rupture of vascular vessels*

1. INTRODUCTION

In this research for blood we accept a non-Newtonian rheological behavior with a variable coefficient of viscosity under the conditions of an unsteady (pulsatile) flow regime, connected with the rhythmic pumping of the blood by the heart. At the same time we admit the incompressibility and homogeneity of the blood while the exterior body forces are neglected.

We also take into consideration the viscoelastic behavior of the limiting walls of the vessels, the whole configuration accepting an axial symmetric geometry versus the vertical axis *Oz*. We use a non-Newtonian mathematical model, elaborated in a previous research and presented in [1]. According to this model the motion equations result from the general Cauchy equations

$$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v}\cdot\nabla\mathbf{v}\right) = div\mathbf{T},$$

where the stress tensor $\mathbf{T} = -p\mathbf{I} + 2(\mu_s + \mu_{RBC})\mathbf{D}$, where **I** is the unit tensor, the scalar *p* is the physical pressure, **D** is the rate of strain tensor, μ_s representing the (constant) plasma viscosity while μ_{RBC} is given by the Cross model, i.e.

$$\mu_{RBC} = \frac{\mu_0^*}{1+(k\dot{\gamma})^{1-n}},$$

with $\dot{\gamma}$ being the shear rate, μ_0^* the viscosity coefficient of the blood, *k* is a time constant and *n* is the index for a shear thinning behavior.

The evolution equations are joined to some boundary conditions which express the existence of a pressure gradient along the *Oz* axis according to the heart beats and implicitly to the rhythmic blood pushing into the vessel (feature which is important in large vessel). Precisely we have

$$\frac{\partial v}{\partial r} = 0 \text{ and } u = 0 \text{ for } r = 0.$$

At $r = R$, due to the viscoelastic behavior of the vessel's wall, the velocity of the blood must be equal to the displacement velocity of the vessel's wall.

The boundary conditions at "edges" $z = 0$ and $z = L$ of the vessel agree with a physiological pulse velocity given by a periodic time-varying function.

To describe the viscoelastic behavior of the vessel's wall we have used the generalized Maxwell model, which is the most general form of the linear model for viscoelasticity [2].

SECTION 4 – Mathematical Modeling

About zeros of some oscillations with dynamic friction

Nicolae MARCOV

University of Bucharest, Faculty of Mathematics and Computer Science
Str. Academiei nr.14, sector 1, 010014, Bucharest, Romania
nmarcov@fmi.unibuc.ro

Abstract: *Consider a second order differential non-linear equation having free boundary value conditions. Let be a solution having infinity of unknown zeros. The integral of energy give the implicit correlation between successive modules of the extreme values of oscillation. The method of successive approximations transforms this correlation into an algorithmic correlation. The decreasing sequence of the modules or local amplitudes converge to zero. For local amplitude of oscillation inside the interval of two successive zeros, the length of the interval is a sum of two improper integrals. In order to obtain the values of these integrals, it is necessary to use series expansions. If the coefficient of dynamic friction is small and the amplitude reached a low enough value, then the polynomial functions are given for numerical calculus of distances between zeros of the oscillation.*

Key Words: *non-linear differential equation.*

1. PROBLEM FORMULATION

Consider the following second order non-linear differential equation with respect to time *t*.

$$\frac{d^2u}{dt^2}+\frac{1}{2}\varepsilon\left|\frac{du}{dt}\right|\frac{du}{dt}+\omega^2\sin u=0 \tag{1}$$

We assume that the coefficients ε and ω are positive constants. If *u* is a solution, then −*u* is also solution. Therefore let us consider the oscillatory solution u: $[\,t_0,\infty\,]\to(-\pi,\pi)$ having following boundary conditions

$$u(t_0)=0,\qquad \frac{du}{dt}(t_0)>0,\qquad u(\infty)=0. \tag{2}$$

This solution has infinity of zeros. Let be $(t_n\,,\,n\in \boldsymbol{N})$ the increasing sequence of zeros of the solution or its derivative and $(a_n,\,n\in \boldsymbol{N})$ the decreasing sequence of local amplitudes.

$$u(t_{2n})=0,\qquad \frac{du}{dt}(t_{2n+1})=0,\qquad a_n=\left|\,u(t_{2n+1})\,\right|. \tag{3}$$

We assume that the maximum value $a_0\in(0,\pi)$ is given.

2. ANALITICAL SOLUTION

In order to obtain the terms of these sequences it is suitable to use the following integral of equation

$$\frac{1}{2}\left(\frac{du}{dt}\right)^2\exp\left(\varepsilon\,u\,sign\left(\frac{du}{dt}\right)\right)+\omega^2V\left(u\,,\varepsilon\,sign\left(\frac{du}{dt}\right)\right)=c(t) \tag{4}$$

The function *V* has the expression

$$V(u,\varepsilon)=\frac{1}{1+\varepsilon^2}\left[1-(\cos u-\varepsilon\sin u)\exp(\varepsilon u)\right]\equiv V(-u,-\varepsilon) \tag{5}$$

The function $c(t)$ is piecewise function. Let c_0 be the constant of integration on interval (t_0,t_1).
From following formula results the missing initial value for given equation.

$$\frac{1}{2}\left[\left(\frac{du}{dt}\right)(t_0)\right]^2=\omega^2V(a_0,\varepsilon)=c_0 \tag{6}$$

Analytical solutions for some problems of optimum with applications in air traffic and economics

Corneliu BERBENTE[1], Sorin BERBENTE[1,2]

[1] "POLITEHNICA" University of Bucharest, Faculty of Aerospace Engineering
Gh. Polizu Street 1-5, 011061, Bucharest, Romania
berbente@yahoo.com
[2]INCAS – National Institute for Aerospace Research "Elie Carafoli"
B-dul Iuliu Maniu 220, Bucharest 061126, Romania
sberbente@incas.ro

Abstract: *Analytical solutions for some problems of optimum with applications in air traffic and economics are given. For air traffic minimal distances between commercial airplanes (flight corridors) are imposed considering various trajectories: straightlines, orthodromes and loxodromes.*
Some other applications are related to target functions submitted to linear or nonlinear restrictions. Although specialized numerical codes exist the analytical solutions are useful giving a more clear understanding, suggesting new ways of approach and providing fast tests for preconception.

Keywords*: flight corridor, target function, linear/ nonlinear restrictions*

1. INTRODUCTION

Analytical solutions for some problems are in general useful, even when specialized numerical codes exist giving a more clear understanding, suggesting new ways of approach and providing fast tests for preconception.

2. OPTIMIZATIONS WITHOUT RESTRICTIONS

Let's consider two airplanes flying on two straight lines trajectories (D1) and (D2), given by the equations:

$$\left(D_1\right)\ \vec{r}_{D1}=\vec{r}_1+\lambda_1\vec{a}_1;\ \left(D_2\right)\ \vec{r}_{D2}=\vec{r}_2+\lambda_2\vec{a}_2, \tag{1}$$

$\vec{r}_i,\lambda_i,\vec{a}_i, i=\overline{1;2}$ being the position vectors of two fixed points fixe *M1* and *M2,* two variable parameters and the direction unit vectors of the two straight lines trajectories, respectively. It is required to determine the minimum distance between the two trajectories, in order to observe the flight corridors (Fig.1).

Solution

The vectors $\vec{r}_{D1},\vec{r}_{D2}$ give the positions of two arbitrary points on trajectories. We shall look for a minimum for the module of the vector $\vec{r}_{D2}-\vec{r}_{D1}$, introducing the target function $F(\lambda_1,\lambda_2)$ equal to the module square as below:

$$F(\lambda_1,\lambda_2)=\left(\lambda_2\overrightarrow{a_2}-\lambda_1\overrightarrow{a_1}\right)^2+2\left(\vec{r}_2-\vec{r}_1\right).\left(\lambda_2\overrightarrow{a_2}-\lambda_1\overrightarrow{a_1}\right)+\left(\vec{r}_2-\vec{r}_1\right)^2 \quad , \tag{2}$$

Because $F(\lambda_1,\lambda_1)$ is pozitive it has always a minimum. In this case necessary extremum conditions are as well:

$$\begin{aligned}&\frac{\partial F}{\partial\lambda_1}=0\ ;\ \lambda_1 a_1^{\,2}-\lambda_2\left(\overrightarrow{a_1}.\overrightarrow{a_2}\right)=\left(\vec{r}_2-\vec{r}_1\right).\overrightarrow{a_1}\\&\frac{\partial F}{\partial\lambda_2}=0;\ -\lambda_1\left(\overrightarrow{a_1}.\overrightarrow{a_2}\right)+\lambda_2 a_2^{\,2}=-\left(\vec{r}_2-\vec{r}_1\right).\overrightarrow{a_2}\end{aligned} \tag{3}$$

Analysis of the chemical equilibrium of combustion at constant volume

Marius BREBENEL

"POLITEHNICA" University of Bucharest, Faculty of Aerospace Engineering
Gh. Polizu Street 1-5, 011061, Bucharest, Romania
mariusbreb@yahoo.com

Abstract: *Determining the composition of a mixture of combustion gases at a given temperature is based on chemical equilibrium, when the equilibrium constants are calculated on the assumption of constant pressure and temperature.*
In this paper, an analysis of changes occurring when combustion takes place at constant volume is presented, deriving a specific formula of the equilibrium constant. The simple reaction of carbon combustion in pure oxygen in both cases (constant pressure and constant volume) is next considered as example of application, observing the changes occurring in the composition of the combustion gases depending on temperature.

Key Words: *mathematical modeling, combustion, chemical equilibrium, thermodynamic properties, internal energy*

1. INTRODUCTION

The mathematical modeling of the chemical reactions usually regards their behavior in reactors where processes are steady, so that the temperature and pressure are constant. The composition of the reaction products at equilibrium is determined by the law of mass action using the equilibrium constants which take into account a constant pressure.

However, there are cases when the reaction is carried out at constant volume (for example, combustion in a piston engine cycle). We will show that, at constant volume, the expressions of equilibrium constant differ from those which are specific to reactions at constant pressure. The influence of the mathematical model changes on the composition of the combustion products, depending on the combustion temperature, will be analyzed in this paper.

2. LAW OF MASS ACTION

We will refer to the law concerning the chemical equilibrium. For a chemical reaction of the form

$$\nu_1' A_1 + \nu_2' A_2 + ... = \nu_1'' A_1 + \nu_2'' A_2 + ... \quad (1)$$

the law of the mass action can be expressed by the equation:

$$K_C = \frac{\prod_i C_i^{\nu_i''}}{\prod_i C_i^{\nu_i'}} \quad (2)$$

where K_C = equilibrium constant in terms of concentrations
C_i = concentrations of species $[\ ]_i$.
ν_i = stoichiometric coefficients

A similar expression of equilibrium constant can be derived in terms of pressures or molar fractions.

The last shows a special interest, since it can be expressed as a function of thermodynamic properties of the reaction participants:

$$K_X = \frac{\prod_i X_i^{\nu_i''}}{\prod_i X_i^{\nu_i'}} \quad (3)$$

where K_X = equilibrium constant in terms of molar fractions (used for reactions in gas phase).
X_i = molar fraction of species $[\ ]_i$.

It is well known that, for the reactions occurring at constant pressure and temperature, the chemical equilibrium is reached then when the Gibbs free energy of the given system gets minim:

Index

SCIENTIFIC COMMITTEE of the Conference

- **Dr. Ruxandra BOTEZ –** École de technologie supérieure, Université de Quebec, Montreal, Canada
- **Dr. Adriana NASTASE** – Aerodynamik des Fluges, RWTH - Aachen, Germany
- **Dr. Ruxandra STAVRE –** Institute of Mathematics "Simion Stoilow" of The Romanian Academy, Bucharest, Romania
- **Dr. Sanda TIGOIU –** University of Bucharest, Romania
- **Dr. Mihai ARGHIR** – Université de Poitiers, France
- **Dr. Stefan BALINT –** West University of Timisoara, Romania
- **Dr. Corneliu BERBENTE** – POLITEHNICA University of Bucharest, Romania
- **Dr. Mircea Dumitrie CAZACU** – POLITEHNICA University of Bucharest, Romania
- **Dr. Sterian DANAILA** – POLITEHNICA University of Bucharest, Romania
- **Dr. Horia DUMITRESCU** – Institute of Mathematical Statistics and Applied Mathematics of The Romanian Academy, Bucharest, Romania
- **Dr. Horia ENE –** Institute of Mathematics "Simion Stoilow" of The Romanian Academy, Bucharest, Romania
- **Dr. Constantin FETECAU –** "Gheorghe Asachi" Technical University, Iasi, Romania
- **Dr. Dorel HOMENTCOVSCHI** – Binghamton University, USA
- **Acad. Marius IOSIFESCU** – Institute of Mathematical Statistics and Applied Mathematics of The Romanian Academy, Bucharest, Romania
- **Dr. Mircea LUPU** – University "Transilvania", Brasov, Romania
- **Dr. Dan MATEESCU –** McGill University, Montreal, Canada
- **Dr. Alexandru MOREGA –** POLITEHNICA University of Bucharest, Romania
- **Dr. Catalin NAE**, INCAS – National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania
- **Dr. Mihai NEAMTU**, INCAS – National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania
- **Dr. Cornel OPRISIU**, INCAS – National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania
- **Dr. Titus PETRILA**, "Babes-Bolyai" University, Cluj-Napoca, Romania
- **Dr. Dan POLISEVSCHI – Institute of Mathematics "Simion Stoilow" of The Romanian Academy, Bucharest, Romania**
- **Dr. Sorin RADNEF**, INCAS – National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania
- **Dr. Ion STROE –** University POLITEHNICA of Bucharest, Romania
- **Dr. Victor TIGOIU** – University of Bucharest, Romania
- **Dr. Ioan URSU**, INCAS – National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania

ORGANIZING COMMITTEE

Prof. Dr. Corneliu BĂLAN

U.P.B. – "Politehnica" University of Bucharest

E-mail: balan@hydrop.pub.ro

http://www.pub.ro

Prof. Dr. Adrian CARABINEANU

University of Bucharest

E-mail: acara@fmi.unibuc.ro

http://www.unibuc.ro/

Dr. Stelian ION

I.S.M.M.A. – Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy "Gheorghe Mihoc - Caius Iacob"

E-mail: ro_diff@yahoo.com

http://www.ima.ro/

Prog. Elena NEBANCEA

INCAS – National Institute for Aerospace Research "Elie Carafoli"

(under the Aegis of the Romanian Academy)

E-mail: nebancea.elena@incas.ro

http://www.incas.ro

Contents

ISSN 2067-4414
ISSN-L 2067-4414

ISSN National Center
Romanian National Library

BUCHAREST

2013