УНИВЕРЗИТЕТ У НИШУ
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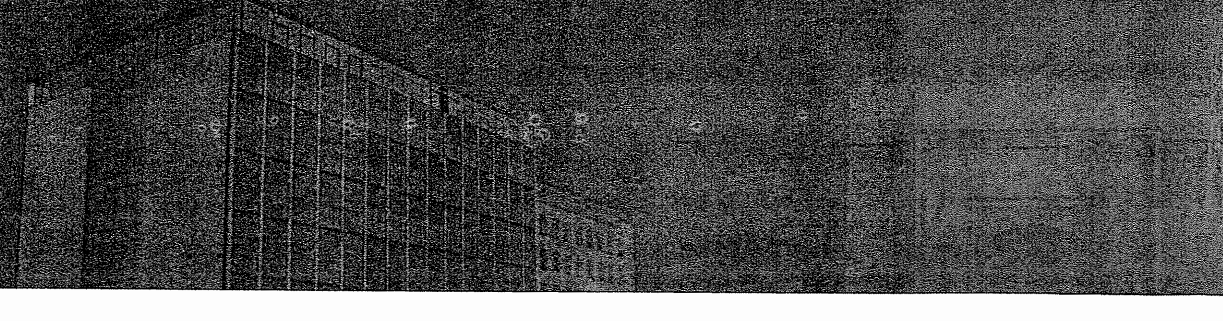
University of Niš
Faculty of Mechanical Engineering

THE INTERNATIONAL CONFERENCE

Mechanical Engineering in XXI Century

PROCEEDINGS

Niš, Serbia, 25 - 26 November 2010.



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UNIVERSITY OF NIŠ
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WITH SUPPORT OF:

Ministry of Science and Technological Development

Chairman of the International conference

Prof. dr Vlastimir NIKOLIĆ, Dean
Faculty of Mechanical Engineering, Niš

SCIENTIFIC COMMITTEE

ORGANIZING COMMITTEE

Publisher:

Faculty of Mechanical Engineering
Prof. dr Vlastimir Nikolić, Dean

Editor:

Prof. dr Dragan Milčić

Technical preparation:

Jelena Milovanović, MSc, teaching assistant
Dragan S. Jovanović, teaching assistant

Design & Prepress:

Saša Đorđević, computer operator

Number of copies:

300

Printing:

"Unigraf"

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

621(082)
621:004(082)
531/534(082)
174:621(082)
007.52(082)

#The #INTERNATIONAL Conference Mechanical Engineering in XXI Century (2010 ; Niš)
Proceedings / The International Conference Mechanical Engineering in XXI Century, 25 - 26 November, Niš, SERBIA ; [organized by University of Niš, Faculty of Mechanical Engineering] . - Niš : Faculty of Mechanical Engineering, 2010 (Niš : Unigraf). - VI, 328 str. : ilustr. ; 30 cm

Tiraž 300. - Napomene uz tekst. - Bibliografija uz svaki rad. - Registar.

ISBN 978-86-6055-008-0
1. Faculty of Mechanical Engineering (Niš)
a) Машинство - Зборници b) Машинство - Рачунарска технологија - Зборници c) Инжењерска етика - Зборници d) Роботика - Зборници
COBISS.SR-ID 179681036

INTRODUCTION SPEECH

Half a century of tradition, high standards in education of generations of students, modernly equipped classrooms, professional teaching and associate staff, their references and recognizability position the Faculty of Mechanical Engineering of the University of Niš at the beginning of the 21^{st} century – the century of knowledge, as the leaders in the field of engineering and technological sciences, not only on the territory of the Republic of Serbia, but also on the territory of the Western Balkans. Knowledge is becoming the number 1 factor in industrial production in the 21^{st} century.

The proceedings of the international conference **MECHANICAL ENGINEERING IN XXI CENTURY** appear in the year when the Faculty of Mechanical Engineering of the University of Niš celebrates its fiftieth anniversary. The Department of Mechanical Engineering of the Faculty of Engineering in Niš was founded on the 18^{th} of May, 1960, and it developed into the Faculty of Mechanical Engineering of the University of Niš in 1971. The Faculty of Mechanical Engineering grew intensely, thus becoming one of the most renowned scientific and educational institutions in the country. The mission of the Faculty is to organize and conduct academic study programmes and to develop and realise scientific and professional work in the field of engineering and technological sciences, while its vision is to become a leader in the area of higher education and scientific research work in Serbia resulting in its being recognisable in the world academic environment.

In the year when the Faculty celebrates fifty years of work, 96 teachers and associates, 65 non-teaching workers, as well as numerous teachers and associates from other faculties and from the industry are working on accomplishing the mission and vision of the Faculty.

The Faculty of Mechanical Engineering of the University of Niš is accredited in compliance with the Law on Higher Education within the scientific and educational field of engineering and technological sciences and the scientific area of mechanical engineering and it conducts the academic studies of:

- the first degree – undergraduate studies, 3 years in duration within a single study programme Mechanical Engineering,
- the second degree – graduate academic studies, 2 years in duration within the study programme Mechanical Engineering, whose completion allows for the competence of a Graduate Mechanical Engineer – Master within the areas of: Energetics and Process Engineering, Information Production Technologies and Industrial Management, Mechanical Constructions, Development and Engineering, Mechatronics and Control, Traffic Engineering, Transport and Logistics,
- master studies of the study programme Control and Applied Computing, 1 year in duration,
- the third degree – doctoral studies, 3 years in duration for the acquisition of the academic title Doctor of Philosophy – Mechanical Engineering, for the specialised areas of: Energetics and Process Engineering, Information Production Technologies and Management, Mechatronics and System Control, Mechanical Constructions, Development and Engineering, Transport, Logistics, Motors and Motor Vehicles, and Applied Mechanics.

The Faculty of Mechanical Engineering is also a scientific research institution apart from being an educational one. Numerous scientific research projects are realised at the Faculty in cooperation with the Ministry of Science and Technological Development, scientific research organisations, and economic and non-economic subjects. The participation of teachers and associates from the Faculty in significant international scientific research projects is of utmost importance (TEMPUS, FP7, WUS, and others).

The international conference **MECHANICAL ENGINEERING IN XXI CENTURY** represents a forum for presentation of latest results, basic and development research and application within the topics of:

- Information Production Technologies and Industrial Management,
- Energetics and Process Engineering,
- Mechatronics and Control,
- Mechanical Constructions, Development and Engineering,
- Traffic Engineering, Transport and Logistics,
- Theoretical and Applied Mechanics,
- Applied Mathematics,
- Professional Engineering Ethics.

Eighty papers, whose authors come from eight countries, are published in these Proceedings. Papers present the research results of numerous projects financed by the Ministry of Science and Technological Development of the Republic of Serbia, as well as the research results within international projects. I believe that the papers published in these Proceedings will contribute to the development of a highly significant area – Mechanical Engineering.

Niš, November 2010.

Dean of the Faculty of Mechanical Engineering
University of Niš
Prof. dr. Vlastimir Nikolić

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AXISYMMETRICAL IONIZED GAS BOUNDARY LAYER IN THE CASE OF VARIABLE ELECTROCONDUCTIVITY

Branko OBROVIĆ, Slobodan SAVIĆ
Faculty of Mechanical Engineering in Kragujevac, University of Kragujevac, Sestre Janjic 6, Kragujevac, Serbia
bobrovic@kg.ac.rs, ssavic@kg.ac.rs

***Abstract**: This paper studies the ionized gas i.e. air flow in an axisymmetrical boundary layer adjacent to the bodies of revolution. The contour of the body within the fluid is nonporous. The ionized gas flows under the conditions of equilibrium ionization. A concrete form of the electroconductivity variation law has been assumed and studied. Through transformation of variables and introduction of sets of parameters, V. N. Saljnikov's version of the general similarity method has been successfully applied. Generalized equations of the axisymmetrical ionized gas boundary layer have been obtained and solved, and some conclusions have been drawn. .*

***Key words**: boundary layer, ionized gas, body of revolution, generalized similarity method*

1. INTRODUCTION

This paper presents results of our investigations of the ionized gas flow in the boundary layer adjacent to the bodies of revolution. The ionized gas flows under the conditions of the so-called equilibrium ionization. The contour of the body within the fluid is nonporous.

The primary objective of this paper is to apply the general similarity method to the studied problem. Investigations are carried out for a concrete form of the electroconductivity variation law.

The general similarity method was first used by Loitsianskii [1] and it was later improved by V. N. Saljnikov [2] - Saljnikov's version. Investigators of Petersburg School of Boundary Layer used this method to solve numerous problems of dissociated gas flow in the boundary layer. This method was also successfully applied to problems of planar dissociated gas boundary layer [3]. Later, investigators of Belgrade School of Boundary-Layer used Saljnikov's version of the boundary layer theory to solve practical problems of flow in the temperature and MHD boundary layer[4]. This version was also used for solution of planar dissociated and ionized gas flow [5-8]. In this paper, Saljnikov's version of the general similarity method is applied.

2. MATHEMATICAL MODEL

The equation system of steady laminar boundary layer adjacent to the bodies of revolution in the case of ionized gas flow in the magnetic field, under the conditions of a equilibrium ionization [5, 10, 11], is as follows:

$$\frac{\partial}{\partial x}\left[\rho u\left(\frac{r}{L}\right)^j\right]+\frac{\partial}{\partial y}\left[\rho v\left(\frac{r}{L}\right)^j\right]=0, \quad (L=const.,\ j=1),$$

$$\rho u\frac{\partial u}{\partial x}+\rho v\frac{\partial u}{\partial y}=\rho_e u_e\frac{du_e}{dx}+\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right)+\sigma B_m^2 u,$$

$$\rho u\frac{\partial h}{\partial x}+\rho v\frac{\partial h}{\partial y}=-u\,\rho_e u_e\frac{du_e}{dx}+\mu\left(\frac{\partial u}{\partial y}\right)^2+ \qquad (1)$$

$$+\frac{\partial}{\partial y}\left(\frac{\mu}{\Pr}\frac{\partial h}{\partial y}\right)+\sigma B_m^2 u^2;$$

$$u=0,\quad v=0,\quad h=h_w=const.\quad \text{for}\quad y=0,$$
$$u\to u_e(x),\qquad h\to h_e(x)\qquad \text{for}\quad y\to\infty.$$

Analogous to the MHD boundary layer, it has been assumed that the electroconductivity variation law can be written in the form of the following function

$$\sigma=\sigma_0\left(1-\frac{u}{u_e}\right),\qquad \sigma_0=const., \qquad (2)$$

where $B_m=B_m(x)$ is the magnetic field power.

In the governing equation system (1), i.e., in the mathematical model, the first equation is a continuity equation of axisymmetrical compressible fluid flow adjacent to the bodies of revolution. It is written in a more suitable form, where L is a characteristic length which can equal unity. The second and third ones are the dynamic and energy equations.

The notation usual in the boundary layer theory is used [9, 10]: x, y - longitudinal and transversal coordinates, $u(x,y)$ - longitudinal projection of the velocity in the boundary layer, $v(x,y)$ - transversal projection, ρ - ionized gas density, p - pressure, μ - dynamic viscosity coefficient, h - enthalpy, $r(x)$ - radius of the body of revolution in the meridian plane (Fig. 1) and $\Pr=\mu c_p/\lambda$ - Prandtl number, where λ - is a thermal conductivity coefficient and c_p - specific heat of the ionized gas. The subscript $''e''$ stands for the physical values at the outer edge of the boundary layer and the subscript $''w''$ denotes the values at the nonporous wall of the body of revolution within the fluid.

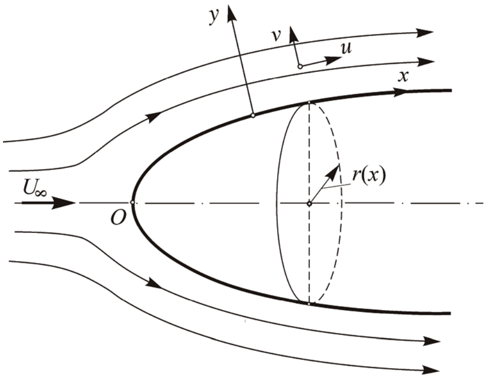

Fig.1. Ionized gas flow adjacent to the body of revolution

3. TRANSFORMATIONS OF THE EQUATIONS

In order to apply the general similarity method, new variables are introduced in the form of

$$s(x)=\frac{1}{\rho_0\,\mu_0}\int_0^x \rho_w\,\mu_w\left(\frac{r}{L}\right)^{2j}dx,\qquad z(x,y)=\left(\frac{r}{L}\right)^{j}\int_0^y \frac{\rho}{\rho_0}\,dy. \tag{3}$$

For $j=0$, they were used in numerous scientific papers [3, 12].

The stream function $\psi(s,z)$ is introduced by the relations:

$$u=\frac{\partial\psi}{\partial z},\qquad \tilde{v}=\frac{1}{(r/L)^{2j}}\frac{\rho_0\,\mu_0}{\rho_w\,\mu_w}\left[u\frac{\partial z}{\partial x}+v\frac{\rho}{\rho_0}\left(\frac{r}{L}\right)^{j}\right]=-\frac{\partial\psi}{\partial s}, \tag{4}$$

which come from the continuity equation. In the transformations (3) and relations (4), the quantities ρ_0 and $\mu_0=\rho_0\nu_0$ denote the known values of the density and dynamic (kinematic) viscosity at a certain point of the boundary layer. Here, ρ_w and μ_w denote the known values of these quantities at the wall of the body of revolution. Using the variables (3) and introducing the stream function $\psi(s,z)$ by the relations (4), the governing equation system (1) takes the following form:

$$\frac{\partial\psi}{\partial z}\frac{\partial^2\psi}{\partial s\partial z}-\frac{\partial\psi}{\partial s}\frac{\partial^2\psi}{\partial z^2}=\frac{\rho_e}{\rho}u_e u_e'+\nu_0\frac{\partial}{\partial z}\left(Q\frac{\partial^2\psi}{\partial z^2}\right)-\frac{1}{(r/L)^{2j}}\frac{\rho_0\mu_0}{\rho_w\mu_w}\frac{\sigma B_m^2}{\rho}\frac{\partial\psi}{\partial z},$$

$$\frac{\partial\psi}{\partial z}\frac{\partial h}{\partial s}-\frac{\partial\psi}{\partial s}\frac{\partial h}{\partial z}=-\frac{\rho_e}{\rho}u_e u_e'\frac{\partial\psi}{\partial z}+\nu_0 Q\left(\frac{\partial^2\psi}{\partial z^2}\right)^2+\nu_0\frac{\partial}{\partial z}\left(\frac{Q}{\Pr}\frac{\partial h}{\partial z}\right)+\frac{1}{(r/L)^{2j}}\frac{\rho_0\mu_0}{\rho_w\mu_w}\frac{\sigma B_m^2}{\rho}\left(\frac{\partial\psi}{\partial z}\right)^2; \tag{5}$$

$$\psi=0,\quad \frac{\partial\psi}{\partial z}=0,\quad h=h_w=const.\quad \text{for}\quad z=0,$$

$$\frac{\partial\psi}{\partial z}\to u_e(s),\quad h\to h_e(s)\quad \text{for}\quad z\to\infty.$$

In the obtained system (5), which for $j=0$ is identical to the corresponding equations for the planar ionized gas flow [13], the nondimensional function Q is determined as

$$Q=\rho\,\mu/\rho_w\,\mu_w=Q(s,z). \tag{6}$$

In order to bring the equation system (5) to a generalized form, the function Φ and the nondimensional enthalpy $\bar{h}$ should be introduced by means of the so-called general similarity transformations. In order to apply the general similarity method, a new transversal variable η and functions Φ and $\bar{h}$ are introduced using the expressions:

$$\eta(s,z)=\frac{B(s)}{\Delta^{**}(s)}z,\qquad \psi(s,z)=\frac{u_e\Delta^{**}}{B(s)}\Phi(\eta,\kappa,(f_k),(g_k)),\qquad h(s,z)=h_1\cdot\bar{h}(\eta,\kappa,(f_k),(g_k)),\quad h_1=const \tag{7}$$

Here, (f_k) denotes a set of parameters of Loitsiantskii type, while (g_k) stands for a set of magnetic parameters [1, 5]. The introduced sets of parameters - *similarity parameters*, are new independent variables (instead of the variable *s*), and they are defined, just like with incompressible fluid with the expressions:

$$f_k(s)=u_e^{k-1}u_e^{(k)}z^{**k},\quad g_k(s)=u_e^{k-1}s^{(k-1)}z^{**k},\quad (k=1,2,3,...). \tag{8}$$

The first parameters $(k=1)$ of the sets (8) stand for the parameter of the form $f_1=u_e'z^{**}=f$ and for the magnetic parameter $g_1=sz^{**}=g$. Here, h_1 is the total enthalpy of the gas in the outer flow. Each set of parameters satisfies the corresponding recurrent simple differential equation [1, 5]:

$$\frac{u_e}{u_e'}f_1\frac{df_k}{ds}=\left[(k-1)f_1+kF_m\right]f_k+f_{k+1}=\theta_k,\qquad \frac{u_e}{u_e'}f_1\frac{dg_k}{ds}=\left[(k-1)f_1+kF_m\right]g_k+g_{k+1}=\gamma_k. \tag{9}$$

In the above stated expressions, the conditional momentum loss thickness $\Delta^{**}(s)$, characteristic boundary layer function *B*(*s*) and local compressibility parameter κ [3] are defined with the relations:

$$\Delta^{**}(s)=\int_0^\infty\frac{u}{u_e}\left(1-\frac{u}{u_e}\right)dz,$$

$$B(s) = \int_0^\infty \frac{\partial \Phi}{\partial \eta}\left(1 - \frac{\partial \Phi}{\partial \eta}\right) d\eta,$$

$$\kappa = f_0 = \frac{u_e^2}{2h_1}, \quad \frac{u_e}{u_e'} f_1 \frac{d\kappa}{ds} = 2\kappa f_1 = \theta_0. \tag{10}$$

Having applied the similarity transformations (7) and taking the expressions (8), (9) and (10) into consideration, the governing equation system (5) is finally transformed into a system in which the distribution of velocity $u_e(s)$ at the outer edge of the boundary layer does not figure explicitly. In that sense, the system is *generalized*. It represents a general mathematical model of the ionized gas flow in the boundary layer adjacent to the bodies of revolution in the case of variable gas electroconductivity defined with the law (2). Since this system cannot be solved numerically, it is solved in a three-parametric ($\kappa = f_0 \neq 0$, $f_1 = f \neq 0$, $g_1 = g \neq 0$, $f_k = g_k = 0$ for $k \geq 2$) twice localized ($\partial/\partial\kappa = 0$, $\partial/\partial g_1 = 0$) approximation. Thus, the obtained system is considerably simplified and it comes down to:

$$\frac{\partial}{\partial \eta}\left(Q\frac{\partial^2 \Phi}{\partial \eta^2}\right) + \frac{aB^2 + (2-b)f_1}{2B^2}\Phi\frac{\partial^2 \Phi}{\partial \eta^2} + \frac{f_1}{B^2}\left[\frac{\rho_e}{\rho} - \left(\frac{\partial \Phi}{\partial \eta}\right)^2\right] - \frac{g_1}{B^2}\frac{\rho_e}{\rho}\left(1 - \frac{\partial \Phi}{\partial \eta}\right)\frac{\partial \Phi}{\partial \eta} = \frac{F_m f_1}{B^2}\left(\frac{\partial \Phi}{\partial \eta}\frac{\partial^2 \Phi}{\partial \eta \partial f_1} - \frac{\partial \Phi}{\partial f_1}\frac{\partial^2 \Phi}{\partial \eta^2}\right),$$

$$\frac{\partial}{\partial \eta}\left(\frac{Q}{\Pr}\frac{\partial \bar{h}}{\partial \eta}\right) + \frac{aB^2 + (2-b)f_1}{2B^2}\Phi\frac{\partial \bar{h}}{\partial \eta} - \frac{2\kappa f_1}{B^2}\frac{\rho_e}{\rho}\frac{\partial \Phi}{\partial \eta} + 2\kappa Q\left(\frac{\partial^2 \Phi}{\partial \eta^2}\right)^2 + \frac{2\kappa g_1}{B^2}\frac{\rho_e}{\rho}\left(1 - \frac{\partial \Phi}{\partial \eta}\right)\left(\frac{\partial \Phi}{\partial \eta}\right)^2 = \frac{F_m f_1}{B^2}\left(\frac{\partial \Phi}{\partial \eta}\frac{\partial \bar{h}}{\partial f_1} - \frac{\partial \Phi}{\partial f_1}\frac{\partial \bar{h}}{\partial \eta}\right); \tag{11}$$

$$\Phi = 0, \quad \frac{\partial \Phi}{\partial \eta} = 0, \quad \bar{h} = \bar{h}_w = const. \quad \text{for} \quad \eta = 0,$$

$$\frac{\partial \Phi}{\partial \eta} \to 1, \quad \bar{h} \to \bar{h}_e(s) = 1 - \kappa \quad \text{for} \quad \eta \to \infty.$$

$$(\Phi = \Phi^{(1)}(\eta, \kappa, f_1, g_1), \quad \bar{h} = \bar{h}^{(1)}(\eta, \kappa, f_1, g_1)).$$

In the equation system (11), the characteristic boundary layer function F_m, nondimensional friction function $\zeta(s)$ and values H and H_1 are determined with the expressions:

$$F_m = 2[\zeta - (2+H)f_1] + 2g_1 H_1, \quad \zeta = B\left(\frac{\partial^2 \Phi}{\partial \eta^2}\right)_{\eta=0},$$

$$H = \frac{A(s)}{B(s)}, \quad H_1 = \frac{A_1(s)}{B(s)},$$

$$A(s) = \int_0^\infty \left(\frac{\rho_e}{\rho} - \frac{\partial \Phi}{\partial \eta}\right) d\eta, \tag{12}$$

$$A_1(s) = \int_0^\infty \frac{\partial \Phi}{\partial \eta}\left(1 - \frac{\partial \Phi}{\partial \eta}\right)\frac{\rho_e}{\rho} d\eta;$$

while a, b are constants.

The obtained *system of approximate generalized equations* (11) is a general mathematical model of the ionized gas flow in the boundary layer adjacent to the bodies of revolution. Due to the localization, the system is solved for in advance given values of the parameters $\kappa = f_0$ and g_1.

Note that the equations of the system (11) are of the same form as the corresponding equations for the case of planar ionized gas flow. For $j = 0$ these equations are the same [13].

4. NUMERICAL SOLUTION, RESULTS

The system differential partial equations of the third order (11) is numerically solved after the order of the dynamic equation has been reduced. For the function Q and the density ration ρ_e/ρ that figure in system (11), approximate dependences [3] have been adopted:

$$Q = Q(\bar{h}) \approx (\bar{h}_w/\bar{h})^{1/3}, \quad \rho_e/\rho \approx \bar{h}/(1-\kappa). \tag{13}$$

Since Prandtl number for air "negligibly depends on the temperature" [3, 5], the equations (11) are solved for a constant value of this number $\Pr = 0{,}712$. For the constants a and b the usual values have been adopted [2]: $a = 0{,}4408$ and $b = 5{,}7140$.

The system of conjugated differential partial equations (11) is solved by finite differences method using the passage method. A concrete solution was based on a program written in FORTRAN.

The system (11) is solved for each cross-section of the boundary layer. Solutions are obtained in tabular form. Only some of the results are presented here in the form of diagrams.

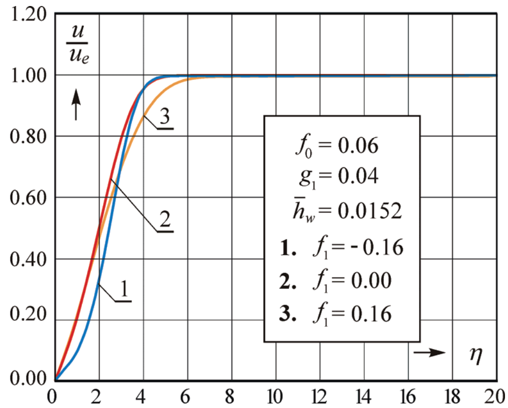

Fig.2. Diagram of the nondimensional velocity u/u_e

Figure 2 shows diagrams of the nondimensional velocity $u/u_e = \partial\Phi/\partial\eta$ at three cross-sections of the boundary layer. The diagram in the Fig 3 represents distribution of the nondimensional enthalpy $\bar{h}$ for three cross-sections of the boundary layer. The influence of the compressibility parameter on distribution of the nondimensional enthalpy $\bar{h}$ is seen in Fig. 4. It shows a diagram of the enthalpy $\bar{h}$ at one cross-section of the boundary layer ($f_1 = 0{,}14$) for three different values ($\kappa = f_0 = 0{,}10;\ 0{,}20;\ 0{,}30$) of that parameter.

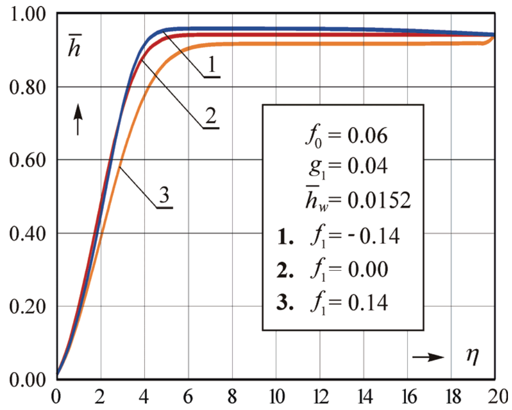

Fig.3. Diagram of the nondimensional enthalpy $\bar{h}$

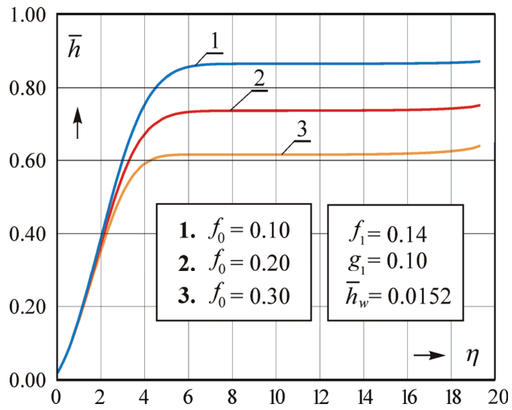

Fig.4. Diagram of the nondimensional enthalpy $\bar{h}$ *for different values of the compressibility parameter* $\kappa = f_0$

5. CONCLUSIONS

Based on the performed investigations and the obtained results, some important conclusions can be drawn. A general conclusion is that V. N. Saljnikov's version of the general similarity method can be successfully applied to the studied flow problem and that the distributions of physical and characteristic quantities have the same behaviour as with other dissociated and ionized gas flow in the boundary layer [3, 13].

There are also some specific conclusions. Firstly, the compressibility parameter has a great influence on the distribution of the nondimensional enthalpy $\bar{h}$ in the boundary layer (Fig. 4). Secondly, the nondimensional flow velocity u/u_e (Fig. 2) at some cross-sections of the boundary layer converges towards unity very fast.

Since the compressibility parameter in the studied case has a big influence on the nondimensional enthalpy (even changes the general behaviour of the distribution of the enthalpy $\bar{h}$!), the obtained boundary layer equations should by all means be solved in a three parametric approximation but without localization per the compressibility parameter. It, however, can be the subject of our further investigations.

REFERENCES

[1] LOITSIANSKII, L. G. (1978) *Liquid and Gas Mechanics* (in Russian), Nauka, Moscow.

[2] SALJNIKOV, V., DALLMANN, U. (1989) *Generalized Similarity Solutions for Three Dimensional, Laminar, Steady Compressible Boundary Layer Flows on Swept, Profiled Cylinders* (in German), Institute for Theoretical Fluid Mechanics, DLR-FB 89-34, Göttingen.

[3] KRIVTSOVA, N. V. (1966) *Parametric Method of Solving the Laminar Boundary Layer Equations with Axial Pressure Gradient in the Conditions of Equilibrium Dissociation of the Gas* (in Russian), Engineering-Physical Journal, Vol.10, pp 143-153

[4] BORIČIĆ, Z., NIKODIJEVIĆ, D., MILENKOVIĆ, D. (1995) *Unsteady MHD Boundary layer on a Porous Surface*, Facta Universitatis, Series Mechanics, Automatic Control and Robotics, Vol.1, No 5, pp 631-643

[5] OBROVIĆ, B. (1994) *Boundary Layer of Dissociated Gas* (in Serbian), Monograph, University of Kragujevac, Faculty of Mechanical Engineering, Kragujevac

[6] SAVIĆ, S., OBROVIĆ, B. (2006) *The Influence of Variation of Electroconductivity on Ionized Gas Flow in the Boundary Layer along a Porous Wall*, Theoret. Appl. Mech., Vol.33, No 2, pp 149-179

[7] OBROVIĆ, B. (2001) *Parametric Method in the Boundary Layer Theory of Ionized Gas whose Electroconductivity is a Function of the Longitudinal Velocity Gradient*, Acta Mech., Vol.147, No 1-4, pp 35-44

[8] OBROVIĆ, B., SALJNIKOV V., BORIČIĆ, Z. (1988) *Boundary Layer Flow of Ideally-Dissociated Chemically "Frozen" Gas - Influence of Pr-Number*, Acta Mech., Vol.71, No 1-4, pp 195-213

[9] DORRANCE, W. H. (1966) *Viscous Hypersonic Flow, Theory of Reacting and Hypersonic Boundary Layers* (in Russian), Mir, Moscow

[10]LOITSIANSKII, L. G. (1962) *Laminar Boundary Layer* (in Russian), FML, Moscow

[11]SCHLICHTING, H. (1974) *Boundary Layer Theory* (in German), G. Braun, Karlsruhe.

[12]OBROVIĆ, B., SAVIĆ, S. (2004) *Ionized Gas Boundary Layer on a Porous Wall of the Body within the Electroconductive Fluid*, Theoret. Appl. Mech., Vol.31, No 1, pp 47-71

[13]OBROVIĆ, B., BORIČIĆ, Z., SAVIĆ, S. (1999) *Boundary Layer of Ionized Gas in the Case of Changeable Electroconductivity*, Facta Universitatis, Series: Mechanics, Automatic Control and Robotics, Vol.2, No 9, pp 953-963

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ISBN 978-86-6055-008-0