University of Banja Luka
Faculty of Mechanical Engineering
Faculty of Electrical Engineering

DEMI 2015

12. International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology

PROCEEDINGS

Banja Luka, 29th - 30th May 2015

CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

621.3(082)(0.034.2)
621(082)(0.034.2)
004(082)(0.034.2)

INTERNATIONAL conference on accomplishments in Electrical and Mechanical Engineering and Information Technology (12 ; Banja Luka) (2015)

Proceedings [Elektronski izvor] = Zbornik radova / 12th International conference on accomplishments in Electrical and Mechanical Engineering and Information Technology, Banja Luka, May 2015 ; [editor in chef Vid Jovišević]. - Banja Luka : University of Banja Luka, Faculty of Mechanical Engineering =Univerzitet u Banjoj Luci, Mašinski fakultet, 2015 (Laktaši : Grafomark). - 1 elektronski optički disk (CD-ROM) : tekst, slika ; 12 cm

CD ROM čitač. - Nasl. sa nasl. ekrana. - Bibliografija uz svaki rad.

ISBN 978-99938-39-53-8

COBISS.RS-ID 5049624

University of Banja Luka
Faculty of Mechanical Engineering
Faculty Of Electrical Engineering

PROCEEDINGS

ZBORNIK RADOVA

Banja Luka, May 2015

Print:
Grafomark, Laktaši

Circulation:
200

ISBN:

12^{TH} INTERNATIONAL CONFERENCE ON ACCOMPLISHMENTS IN ELECTRICAL AND MECHANICAL ENGINEERING AND INFORMATION TECHNOLOGY

Supported by:
MINISTRY OF SCIENCE AND TECHNOLOGY OF
THE REPUBLIC OF SRPSKA

Organizer and publisher:
FACULTY OF MECHANICAL ENGINEERING
UNIVERSITY OF BANJA LUKA

Co-organizer:
FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITY OF BANJA LUKA

For publisher:
Prof. Darko Knežević, PhD

Editor in chief:
Prof. Vid Jovišević, PhD

Executive editor:
Biljana Prochaska, MSc

Editorial assistant:
Milivoj Stipanović

ORGANIZATIONAL COMMITTEE

Chairman:

Prof. Vid Jovišević, PhD, Faculty of Mechanical Engineering Banja Luka

Secretary:

Biljana Prochaska, MSc, Faculty of Mechanical Engineering Banja Luka

Members:

Prof. Zdravko Milovanović, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Darko Knežević, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Snežana Petković, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Petar Gvero, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Mladen Todić, PhD, Faculty of Mechanical Engineering Banja Luka
Assist. Prof. Zoran Đurić, PhD, Faculty of Electrical Engineering Banja Luka
Prof. Aleksandar Milašinović, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Mihajlo Stojičić, PhD, Faculty of Mechanical Engineering Banja Luka
Assist. Prof. Zorana Tanasić, PhD, Faculty of Mechanical Engineering Banja Luka
Assist. Prof. Strain Posavljak, PhD, Faculty of Mechanical Engineering Banja Luka
Assist. Prof. Đorđe Čiča, PhD, Faculty of Mechanical Engineering Banja Luka
Biljana Vranješ, MSc, Faculty of Mechanical Engineering Banja Luka
Branislav Sredanović, MSc, Faculty of Mechanical Engineering Banja Luka
Slaviša Todorović, Faculty of Mechanical Engineering Banja Luka
Goran Jotić, Faculty of Mechanical Engineering Banja Luka
Branislav Jovković, University of Banja Luka
Milivoj Stipanović, Faculty of Mechanical Engineering Banja Luka.

PROGRAM AND SCIENTIFIC COMMITTEE

Chairman:

Prof. Ostoja Miletić, PhD, Faculty of Mechanical Engineering Banja Luka, BiH.

Members:

Prof. Duško Lukač, PhD, University of Applied Science, Köln, /Germany/
Prof. Simo Jokanović, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Miloš Kojić, PhD, Harvard University, /USA/
Prof. Milorad Božić, PhD, Faculty of Electrical Engineering Banja Luka
Prof. Petar Marić, PhD, Faculty of Electrical Engineering Banja Luka
Prof. Bobrek Miroslav, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Ćosić Ilija, PhD, University of Novi Sad, /RS/
Prof. Hadžistević Miodrag, PhD, University of Novi Sad, /RS/
Prof. Soković Mirko, PhD, University of Ljubljana, /SL/
Prof. Milenko Stegić, PhD, University of Zagreb, /RH/
Prof. Ivan Filipović, PhD, University of Wien, /Austria/
Prof. Dušan Gruden, PhD, TU
Prof. Branko Blanuša, PhD, Faculty of Electrical Engineering Banja Luka
Prof. Čedomir Zeljković, PhD, Faculty of Electrical Engineering Banja Luka
Prof. Radivoje Pešić, PhD, University of Kragujevac, /RS/
Prof. Stevan Veinović, PhD, University of Kragujevac, /RS/
Prof. Solvang Björn, PhD, Narvik University, /Norway/
Prof. Ljubiša Papić, PhD, University of Kragujevac, /RS/
Prof. Petar Gvero, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Milan Radovanović, PhD, Society of Thermal Engineers, /RS/
Prof. Vladimir Savić, PhD, University of Novi Sad, /RS/
Prof. Zdravko Milovanović, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Janez Kopač, PhD, University of Ljubljana, /SL/
Prof. Milan Zeljković, PhD, University of Novi Sad, /RS/
Prof. Velimir Todić, PhD, University of Novi Sad, /RS/
Prof. Milentije Stefanović, PhD, University of Kragujevac, /RS/
Prof. Snežana Petković, PhD, Faculty of Mechanical Engineering Banja Luka
Assist. Prof. Strain Posavljak, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Miodrag Manić, PhD, University of Niš, /RS/
Prof. Emilia Assenova, PhD, Technical University of Sofia, /Bulgaria/
Prof. Bogdan Nedić, PhD, University of Kragujevac, /RS/
Prof. Marius Benea Calin, PhD, Faculty of Engineering Hunedoara, /Romania/
Prof. Konstantinos-Dionysios Bouzakis, PhD, AU Thessaloniki, /Greece/
Prof. Dragan Milutinović, PhD, University of Belgrade, /RS/
Prof. Vid Jovišević, PhD, Faculty of Mechanical Engineering Banja Luka
Prof. Ranko Zrilić, PhD, Faculty of Mechanical Engineering Banja Luka

CONTENT

KEYNOTE LECTURES

PRODUCTION AND COMPUTER-AIDED TECHNOLOGIES

ENERGETICS AND THERMAL ENGINEERING

AUTOMOTIVE AND TRAFFIC ENGINEERING

QUALITY AND ECOLOGY

MAINTENANCE OF ENGINEERING SYSTEMS AND OCCUPATIONAL SAFETY ENGINEERING

PREFACE

The contemporary development of a society requires increased productivity and production quality in all fields of industry. In electrical and mechanical engineering as well as information technology this is most obvious in basic production processes and other engineering activities. In the last decades, new techniques and technologies have seen intensive advance and their application in production systems has also been increasing.

Contemporary production is nowadays computer integrated by applying software that enables simultaneous product and manufacturing process design and complete CAD/CAPP/CAM integration of design and production.

These accomplishments, present in the developed countries, are within reach and can be acquired by intensifying our education, scientific research and development efforts, which include presenting the most important results of the past few years at this Conference.

The DEMI conference is a major meeting for presentation of new research and development results in electrical and mechanical engineering as well as information technology. The aim of the DEMI 2015 Conference is to present scientific and professional accomplishments and possibilities for their application, but also to set course for future research and development, in order to improve manufacturing aspects of industry by introducing new technologies.

The Conference includes the following thematic fields:

- Production and Computer-Aided Technologies
- Energetics and Thermal Engineering
- Mechanics and Design
- Mechatronics and Information Technology
- Automotive and Traffic Engineering
- Quality and Ecology
- Maintenance of Engineering Systems and Occupational Safety Engineering

117 papers will be presented at the Conference. The fact that there are 89 papers submitted from abroad reflects the international character of the Conference.

The DEMI 2015 Conference is an opportunity for researchers and engineers, both from the academic community and industry, to get together, to exchange experiences and to define the state of affairs in the industry as well as to create preconditions for the development of new capacities and ambient for new investments.

The Ministry of Science and Technology of the Republic of Srpska has supported the organization of this Conference, thus contributing to the improvement of scientific-research and development activities in the field of electrical and mechanical engineering as well as information technology for which the organizer of the Conference is very grateful.

On behalf of the Organizing Committee of the Conference, we would like to express our gratitude to all domestic and foreign authors as well as to the members of referee teams for their reviews.

In Banja Luka, 20 May 2015

Chairman of the Organizing Committee
Prof. Vid Jovišević, PhD

PREDGOVOR

Savremeni razvoj društva nameće potrebu stalnog povećanja produktivnosti i kvaliteta proizvodnje u svim industrijskim granama. U oblasti elektrotehnike, mašinstva i informatike to posebno dolazi do izražaja u osnovnim proizvodnim procesima i u procesima inženjerske djelatnosti. U posljednjim decenijama ostvaren je intenzivan razvoj novih tehnika i tehnologija i njihove sve veće primjene u proizvodnim sistemima.

Savremena proizvodnja je danas kompjuterski integrisana primjenom programskih sistema koji omogućuju simultano projektovanja proizvoda i tehnoloških procesa, i postizanje potpune integracije /CAD/CAPP/CAM/ projektovanja i proizvodnje.

Ova dostignuća u industrijski razvijenim zemljama moguće je dostići inteziviranjem domaćih napora u oblasti obrazovne, naučno-istraživačke i razvojne djelatnosti, što se ostvaruje prikazivanjem na ovoj Konferenciji najvrednijih rezultata koji su postignutu proteklih godina.

Konferencija DEMI predstavlja vodeći skup za prezentaciju novih rezultata istraživanja i razvoja u oblasti elektrotehnike, mašinstva i informatike. Cilj konferencije DEMI2015 je da se prikažu naučna i stručna dostignuća i mogućnosti njihove primjene, da se odrede pravci daljeg istraživanja i razvoja u cilju podizanja tehnološkog nivoa industrije uvođenjem novih tehnologija

Konferencija obuhvata sljedeće tematske oblasti:

- Proizvodne i računarom podržane tehnologije
- Energetika i termotehnika
- Mehanika i konstrukcije
- Mehatronika i informatika
- Automobilski i saobraćajni inžinjering
- Kvalitet i ekologija
- Održavanje tehničkih sistema i inženjerstvo zaštite radne sredine

Na Konferenciji će biti izloženo ukupno 117 rada. Iz 9 inostranih zemalja je prijavljeno 89 radova, što ukazuje na međunarodni karakter Konferencije.

Konferencija DEMI2015 je prilika za okupljanje istraživača i inženjera sa akademske zajednice i industrije, u cilju razmjene iskustava i definisanja stanja u oblasti industrije i stvaranja preduslova za razvoj novih kapaciteta i ambijenta za nove investicije.

Ministarstvo nauke i tehnologije Republike Srpske je svojom podrškom omogućilo organizovanje ove Konferencije, što daje doprinos unapređenju naučno-istraživačke i razvojne djelatnosti u oblasti elektrotehnike, mašinstva i informatike, na čemu im se organizator Konferencije zahvaljuje.

U ime Organizacionog odbora Konferencije posebno se zahvaljujemo svim domaćim i stranim autorima, kao i članovima recezentskog tima na izvršenim recenzijama.

U Banjoj Luci, 20.05.2015. godine

Predsjednik organizacionog odbora
Prof. dr Vid Jovišević

University of Banja Luka
Faculty of Mechanical Engineering

DEMI 2015
12. International Conference
on Accomplishments
in Electrical and
Mechanical Engineering
and Information Technology

NUMERICAL SOLUTION OF MATHEMATICAL MODEL FOR FLUID FLOW AND HEAT TRANSFER PROCESSES IN PLATE EHCHANGER BASE ON STREAMLINE – VORTEX METHOD

Cvete B. Dimitrieska [1], Igor Andreevski, Sanja P. Vasilevska, Sevde Stavreva[2]

***Summary**: Analytical solution of system equations which defined fluid flow and heat transfer processes, are elliptical and parabolic differential equations, based on initial and boundary conditions is unusual familiar in closed form. Numerical solution of equation system is necessary by discretization of equations.*

When system of equations relate with engineering problems, especially for estimation of two dimensional stationary problems, manage method for estimation of elliptical differential equations, with Poisson formulation for streamline – vortex ψ , ω , in base two – dimensional form is recommended.

Key words: fluid flow, heat transfer, mathematical model, vortex, streamline, numerical solution

1. INDRODUCTION

When systems of equations are related with engineering problems, especially for two- dimensional stationary fluid – flow processes in heat plate exchanger, using of Poisson formulation for streamline – vortex ψ, ω, [3], [5], [6], for elliptical differential equations in base two dimensional form, is recommended.

On that manner of solution, exchange of velocity components with vortex ω and streamline ψ is assigned.

The vector of the vortex is defined like, [3]:

$$\omega = \nabla \times \mathbf{u} \tag{1}$$

By using of the Cauchy - Riemann conditions of the velocity potential, [3]:

$$\frac{\partial \psi}{\partial x} = -v \text{ and } \frac{\partial \psi}{\partial x} = u \tag{2}$$

for two – dimensional stationary fluid flow next to vortex existing, by using two-dimensional continuity equation, for scalar vortex and streamline are obtained:

[1] Associate prof. Cvete Dimitrieska, PhD, Faculty of Technical Sciences – Bitola, cvete.stefanovska@tfb.uklo.edu.mk

[2] Associate prof. Igor Andreevski PhD, Associate prof. Sanja P. Vasilevska, PhD, Ass. prof. Sevde Stavreva, PhD, igor.andreevski@tfb.uklo.edu.mk, pvsanja@yahoo.com, stavrevasevde@gmail.com, Faculty of Technical Sciences – Bitola

$$u\frac{\partial \omega}{\partial x}+\mathrm{v}\frac{\partial \omega}{\partial \mathrm{y}}=\nu\left(\frac{\partial^2 \omega}{\partial x^2}+\frac{\partial^2 \omega}{\partial y^2}\right) \quad (3)$$

Equation (3) is parabolic differential equation, well known vortex-transport equation, [3].

By ordering of (2) and (3), streamline equation is obtained:

$$\frac{\partial^2 \psi}{\partial x^2}+\frac{\partial^2 \psi}{\partial y^2}=-\omega \qquad \Delta\psi=-\omega \quad (4)$$

As a result of variable substitute, pressure elimination of base system is possible (which is often problem), and then second step is dividing of elliptic- parabolic incompressible equations on one parabolic and one elliptic equation. Those equations are mostly calculated by using of next procedure:

1. Ordering of initial values for ω and ψ;
2. Calculation of vortex – transport equation;
3. Calculation of Poisson's equation for ψ in all points, by using of new values for ω in interior points;
4. Determination of boundary value of ω by using of values for ω and ψ in interior points;
5. Back to step 2 if solution in no converge able;
6. Determination of velocity component values, *u* and v.

Idem means setting for next estimation, getting values of pressure and temperature distribution, for estimated values of velocity in x and y direction, in area of definition, under known boundary conditions.

2. SOLUTION OF THE MODEL

For system equation solution, on that way of problem formulation, two methods are known. The direct methods, where Gauss method of elimination belong and Cramer rule are characterized with large number of arithmetical operations and a lot of time for calculation for getting results. On the other side, iterative methods are more simplified for programing, the calculation take shortly with satisfactory accuracy, [2], [3].

According [5], [6] known iterative methods for numerical solution of system of elliptical differential equations and calculation of stream - velocity potential are: Jacobi iterative method, point iterative method Point Seidel, linear iterative method, Line Siedel and ADI method (Alternating Direct Implicit Method).

Under defined initial and boundary conditions for area of streaming, for problem estimation, ADI method was used, which is more useful and adequate for rectangular cross section channel with defined contour.

Under defined initial and boundary conditions for area of streaming, for problem estimation, ADI method was used, which is more useful and adequate for rectangular cross section channel with defined contour.

Based on ADI method, for calculation of two dimensional problems, estimation of system of elliptical equations is similar with estimation of system of parabolic equations. Estimation of Poisson equation is postulated on approximation of derivation of the stream line ψ of second order, base on method of finite differences:

$$\frac{\partial^2\psi}{\partial x^2} \approx \frac{\psi_{i-1,j} - 2\psi_{i,j} + \psi_{i+1,j}}{(\Delta x)^2}$$
$$\frac{\partial^2\psi}{\partial y^2} \approx \frac{\psi_{i,j-1} - 2\psi_{i,j} + \psi_{i,j+1}}{(\Delta y)^2} \quad (5)$$

By summing of equations in (5) and identification with (4), according condition $\Delta x = \Delta y$, final form of Poisson equation is related:

$$\psi_{i,j} = \frac{\psi_{i-1,j} + \psi_{i,j-1} + \psi_{i+1,j} + \psi_{i,j+1} + \omega_{i,j}\Delta x\Delta y}{4} \quad (6)$$

Thereby, values of stream line ψ in node i, j depend of values of neighboard nodes in its area, Fig. 1 and values of the vortex ω in the node. Gauss – Seidel iteration and TDMA method (Tridiagonal Matrix Algorithm Method) are used to find solution of the problem.

In the TDMA form, the equation (6) is reduced as:

$$\psi_{i,j-1} - 4\psi_{i,j} + \psi_{i,j+1} = -\psi_{i-1,j} - \psi_{i+1,j} - \omega\Delta x\Delta y \quad (7)$$

Registered in general form, by introduction of main variable u, equation (7) get form:

$$a_i\mathbf{u}_{i-1} + b_i\mathbf{u}_i + c_i\mathbf{u}_{i+1} = d_i \quad (8)$$

where a_i, b_i, c_i and d_i are coefficients of the finite elements differences.

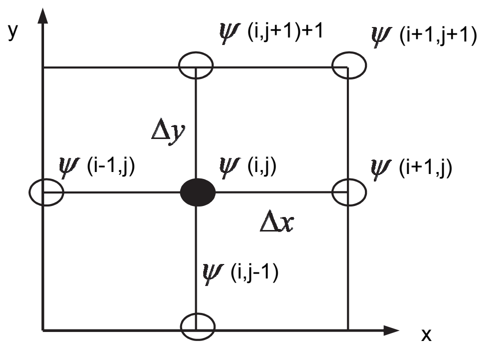

Fig. 1 *Schema of 2D finite differences for Poisson formulation*

That method is similar with Gauss method elimination, but it is more accurate. By introduction of dependence, [3]:

$$\mathbf{u}_{i-1} = e_i\mathbf{u}_i + f_i \quad (9)$$

where upon:

$$e_{i+1} = \frac{-c_i}{a_ie_i + b_i} \qquad f_{i+1} = \frac{d_i - a_if_i}{a_ie_i + b_i} \quad (10)$$

The procedure is reduced to numerical estimation and getting of values for ψ, ω in any interior node in area of interest. Starting from line i=2, mention that constant *di* in three agonal equation is composed of known values for $\psi_{1,j}$ and estimated values for $\psi_{3,j}$. By using of TDMA new value for $\psi_{2,j}$ is obtained.

Procedure are repeated for i=3, by using of values for $\psi_{2,j}$ for assumed of last estimated value for $\psi_{4,j}$. The procedure are repeated step by step, line by line, until exiting of the channel.

During estimation, criteria for convergation from old to new value must be kept, base on definied value of allowed error ε:

$$\sum_{i,j} \left| \psi_{new} - \psi_{old} \right| < \varepsilon \tag{11}$$

Base on the same analogy, values of vortexes in all nodes of generated grid are estimated. But have in mind that, stream line and vortexes are depended between each other.

2.1 ADI METHOD

Base on ADI method, estimation of main parameters: velocity and pressure, are reduced on arithmetical estimation of new system of equations.

For calculation of the velocities are in use two equations:

$$\begin{aligned} u_{i,j} &= \frac{\psi_{i,j+1} - \psi_{i,j-1}}{2\Delta y} \\ \mathrm{v}_{i,j} &= -\frac{\psi_{i+1,j} - \psi_{i-1,j}}{2\Delta x} \end{aligned} \tag{12}$$

for related value of initial velocity in the module of examination.

For the pressure estimation next equations are in use, [3], [5], [6]:

$$p_{i,j}^{n+1} = \frac{1}{4}\left(p_{i+1,j}^{n} + p_{i-1,j}^{n} + p_{i,j+1}^{n} + p_{i,j-1}^{n} + 2\Delta x^2 \psi(i,j)(d \cdot e - f^2) \right) \tag{13}$$

there for:

$$\begin{aligned} d &= \frac{\psi_{i+1,j} - 2\psi_{i,j} + \psi_{i-1,j}}{\Delta x^2} \\ e &= \frac{\psi_{i,j+1} - 2\psi_{i,j} + \psi_{i,j-1}}{\Delta y^2} \\ f &= \frac{\psi_{i+1,j+1} - \psi_{i+1,j-1} - \psi_{i-1,j+1} + \psi_{i-1,j-1}}{4\Delta x \Delta y} \end{aligned} \tag{14}$$

for known base value of pressure p, for given temperature t.

Estimation of energetic equation, concerning two – dimensional temperature field, is in relation with explicit knowing of velocity values in x and y direction in any node of the generated grid. The energetic equation is parabolic differential equation, whose estimation is well known in many engeneering problems in literature, [3] and [4].

Two – dimensional temperature field are related with values of local convective heat transfer coefficients, local velocity values and local Re number in any node of the generated grid. For known input fluid temperature and inside plate temperature (both temperatures are measurable), termophysic characteristics are optained, Pr number is calculated, than Nu number, and the convective coefficient. A lot of empirical and semy empirical relations exsist about forced turbulent flow of uncomprecable heated fluid (20-300°C) in channel with rectangular cross section between two parallel plates, [1], [3], but in this paper next relations are in use:

- local Re number for channel flowing:

$$\mathrm{Re}(i,j)=\frac{\mathrm{w(i,j)}\delta}{\nu(t_o)} \tag{15}$$

There for, w(i,j) is a resultant local velocity of the fluid in any node, δ is characteristic destination between parallel plates, $\nu(t_o)$ is kinematic fluid viscosity for initial input temperature t_o:

- local Nu number base on [1], [3]:

$$Nu(i,j)=0.021\varepsilon_l\,\mathrm{Re}(i,j)^{0.8}\,\mathrm{Pr}(t_o)^{0.43}\left(\frac{\mathrm{Pr}(t_o)}{\mathrm{Pr}_z(t_{oz})}\right)^{0.25} \tag{16}$$

There for, ε_l is correction related with channel geometry and Re number, $\mathrm{Pr}(t_o)$ for input temperature t_o, $\mathrm{Pr}(t_{oz})$ for fluid temperature from interior and exterior side of the plate. There for, for known thermophysic characteristics of the fluid for wall temperature, $\mathrm{Pr}(t_{oz})$ number is defined according:

$$\mathrm{Pr}_z(t_{oz})=\frac{c_p(t_{oz})\eta(t_{oz})}{\lambda(t_{oz})} \tag{17}$$

Where c_p is specific heat under constant pressure, η is dynamic vicsosity, λ heat conductivity for fluid temperature on the interior side of the plate.

Local heat transfer coefficient is estimated according:

$$\alpha(i,j)=0.021\varepsilon_l\,\mathrm{Re}(i,j)^{0.8}\,\mathrm{Pr}(t_o)^{0.43}\left(\frac{\mathrm{Pr}(t_o)}{\mathrm{Pr}_z(t_{oz})}\right)^{0.25}\frac{\lambda(t_o)}{\delta} \tag{18}$$

For known measurable values of fluid and plate temperatures on interior and exterior sides of the module, as well for known thickness and heat conductivity of the plate material, constant heat transfer flux is defined:

$$q=\alpha_v(i,j)(t_v(i,j)-t_z^v)=\frac{\lambda_m}{\delta_m}(t_z^v-t_z^n)=\alpha_n(i,j)(t_z^n-t_n(i,j))=const \tag{19}$$

Heat transfer is in direction according:

$$t_v(i,j)>t_z^v>t_z^n>t_n(i,j) \tag{20}$$

There for, $\alpha_v(i,j)$ is local heat convective coefficient of the heated gass on the interior side of the plate; $\alpha_n(i,j)$ is the local convective coeficient of heat transfer from the exterior side of the plate in direction of the gass with lower temperature; $t_v(i,j)$, is the temperature of the fluid on the interior side with the higher temperature where hot gass streaming; $t_n(i,j)$ is the temperature of the fluid with lower temperature; λ_m is the conductive coefficient of the material – sheet metal; δ_m thicknees of the material – sheet metal.

For initial values of the inlet fluid temperature, on the interior or exterior side, there for temperatures of the plate from both sides, under estimated local values of the coefficients of heat transfer, local values od the fluid temperature in any nodes on the both sides are calculated.

Because estimation start with assumption of the inlet fluid temperature, with numerical iterative calculation, step by step, by the corection, real values of the tempertaure in the nodes will be related.

Under flowing on the flat plate, local heat transfer coefficients are estimated:

$$k(i,j) = \left(\frac{1}{\alpha_v(i,j)} + \frac{\delta_m}{\lambda_m} + \frac{1}{\alpha_n(i,j)} \right)^{-1} \tag{21}$$

By using of the known values of the local heat transfer coefficients and know temperature difference on internal and external side of the plate, local values for the heat power of the heat exchanger in any nodes of the grid :

$$q(i,j) = k(i,j)\left[\ t_v(i,j) - t_n(i,j)\ \right] \tag{22}$$

Base on presented procedure for calculation of the local velocity values, local pressure values, temperature in any nodes of the generated grid from the both sides of the module can be estimated.

3. CONCLUSION

The postulated mathematical model in discretized form is in adequate numerical form for programme solution.

The local values of the temperature in any node of the grid, for known velocity field and pressure values are estimated according known procedure. For known values of Re and Nu numbers, there for defined local values of heat transfer coefficients, under known thermophysical fluid characteristics and sheet metal for temperature values in inlet, of interior and interior side of the module – performed like heat plate exchanger, and for wall temperatures from the other sides, temperature distribution in nodes are estimated.

The procedure is repeated with iterations, until satisfactory accuracy of the temperature values are related.

REFERENCES

[1] Лыков А. В. (1978): *Тепломасообмен – Справочник*, Энерия – Москва.

[2] A. Bejan (1993): *Advanced Engineering Mathematics*, Seventh edition, John Wiley & Sons, INC.

[3] S. R. Ransau: *Solution Methods for Incompressible Viscous Free Surface Flows*: A Literature Review; Preprint Numeric No.3/2002, Norwegian University of Science and Technology, Trondheim, Norway

[4] *Computational Fluid Dynamics,* NASA Langley Research Center in Hapmton, V. A.; Fluid Mechanics and Acoustics Division, 2005, USA

[5] L. Lapidus, G. F. Pinder (1982): *Numerical Solution of Partial Differential Equations in Science and Engineering*, Princeton University, John Wiley&Sons.

[6] Numerical Solution of Navier-Stokes equation using FEMLAB, Umea University, Department of Physics, Staffan Grundberg, 2002