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CONTENTS

Technical Sciences

Economic Sciences

Philological Sciences

Pedagogical Sciences

Geosciences

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Data Set Analysis of Electric Power Consumption*

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Abstract. This paper presents the analysis of the dataset that is the consumption of electrical power in one household within practically four years in order to find out some patterns, cyclical or seasonal features or other significant information that allows us to do forecasting of the future demand with the certain degree of accuracy.

Keywords: electrical energy; analysis; forecasting; time-series; Box and Jenkins approach; ARIMA modelling.

Introduction

Nowadays practically all European countries while providing energy effective policy are concerned about reducing the total demand of energy consumption with maintaining the high level of development. Since the sector of individual consumption is one of the largest consumers of electric energy, the rational consumption of electricity at home becomes of a great importance.

The first step of rational consumption of electric energy is analyzing the level of electricity demand in order to predict future demand of electricity with a high degree of accuracy. Forecasting of the future demand can help making decisions for improving energy efficiency at home, choosing

* From 23.06.2013 on 01.07.2013 Perm National Research Polytechnic University (PNRPU) in collaboration with the University of Applied Sciences (UAS) Anhalt (Germany) held an International summer school "Information Management". During the school were conducted master classes by leading professors of UAS Anhalt, UAS Hamburg, PNRPU, Bauman Moscow State Technical University. Perm and German universities' students enrolled in the "double degree" program, presented papers on the subject of research at the partner universities. The best 3 papers are presented in this journal.

the right class of the household equipment. Forecasting is also significant instrument for effective and rational planning of the budget.

Concrete task

The task to be solved in this paper is to analyze the dataset that is the consumption of electrical power in one household located in the Clamart, France (southwestern suburb of Paris) within practically four years (since December 2006 till November 2010) in order to find out some patterns, cyclical or seasonal features or other significant information that allows to do forecasting of the future demand with the certain degree of accuracy. The source of the data is the UCI Machine Learning Repository [1, 2].

Time-series data

The dataset represents the measurements of electric power consumption in one household with a one-minute sampling rate over a period of practically four years. The data presents different electrical quantities and some sub-metering values and is a typical representative of a time-series data that can be defined as a sequence of observed values. One of the most distinctive features of the time-series is that data is not generated independently; their dispersion varies in time, and often is governed by a trend and has cyclic components. An observed time series can be decomposed into three components: the trend (long term direction), the seasonal (systematic, calendar related movements) and the irregular (unsystematic, short term fluctuations).

Forecasting process

Forecasting is a process of estimating the unknown. It can be defined as the science of predicting future outcomes. Forecast should be fitted with the following characteristics: it should be timely, it should be as accurate as possible; it should be reliable; it should be in meaningful units. In order to do the forecasting process the following steps should be computed [3, 4]:

1. definition of the purpose of the forecasting;
2. data preparation;
3. preliminary analysis;
4. choosing and fitting the best model;
5. forecasting;
6. evaluation.

Data preparation

For analyzing the consumption of electrical power in the household the following attributes are required: date, time and active power as an electrical parameter that strongly depends on the electrical demand. In order to do the preliminary analysis the average daily temperature for each instance is added to the database. The source is the site with the archive of average temperature TuTiempo.

In the database there are missing values of about 1,25 % of the rows that were fulfilled with the previous values using the possibilities of R that is a free software environment for statistical computing and graphics for different platforms [5].

Preliminary analysis

The good way for understand the data is visualization in order to find out some consistent patterns or significant trend and to understand whether seasonality is important or if there is an evidence of some cycles.

With the help of Tableau 8.0 that is a powerful statistic tool for exploration and visualization of the datasets the graphics for the different time periods are constructed. To aggregate data values to the required time period the median of the active power is used. For example, figure 1 shows month graphic of the median of active power in comparison with average temperature.

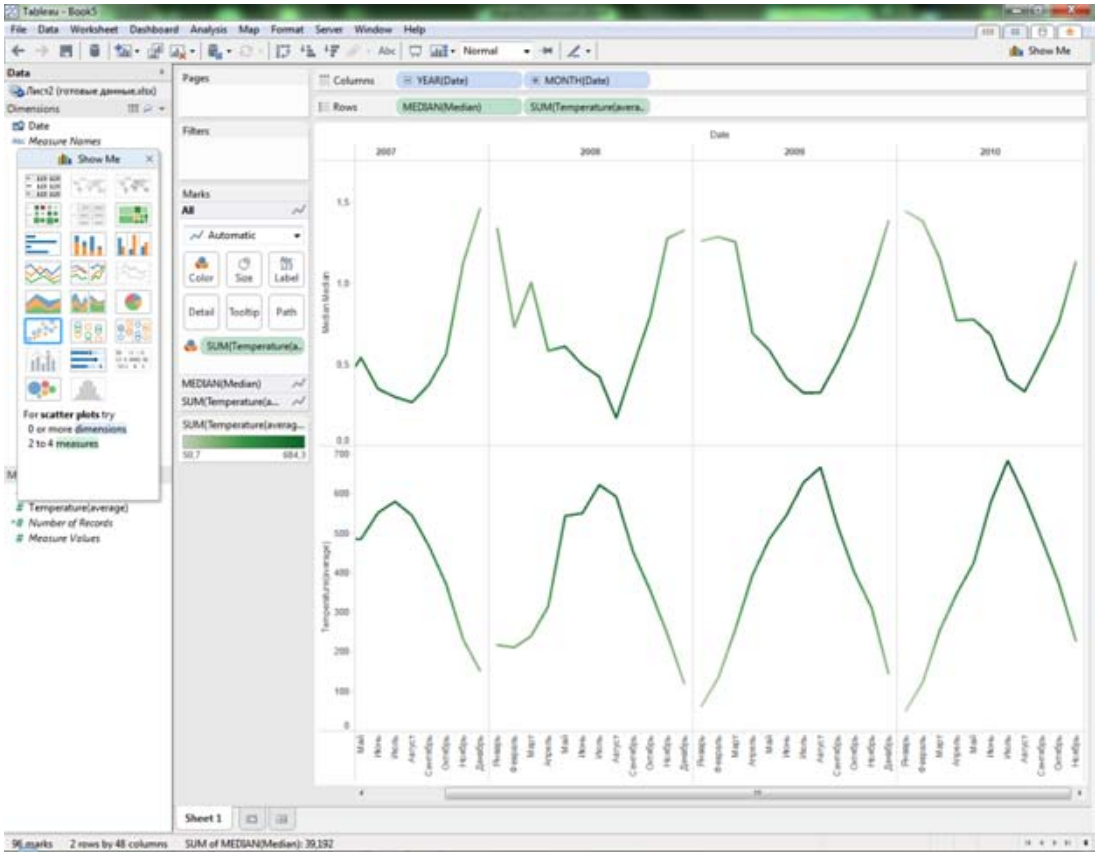

Fig. 1. Month graphic of the median of active power with average temperature

The most interesting from the practical point of view is probably the analysis of the day and week consumption that can be used in the future forecasting. Additionally there is enough data for doing the forecasting of the future demand; all in all there are 207 weeks and 1442 days in the observed period.

The results of the preliminary analysis show that active power of electrical demand is strongly seasonal dependent, some trend can be definitely observed there and also some random factor influences data distribution.

Decomposition of the data is frequently used for analysing the time-series data that contains trend, seasonal and the irregular components. Using Tableau 8.0 we receive several smaller datasets for analysing day and week consumption that have an appropriate form for doing decomposition. With the help of R the time-series objects with the required length and frequency are created and decomposed.

The results of decomposition with respect to days and weeks periods are presented in the figure 2 and 3.

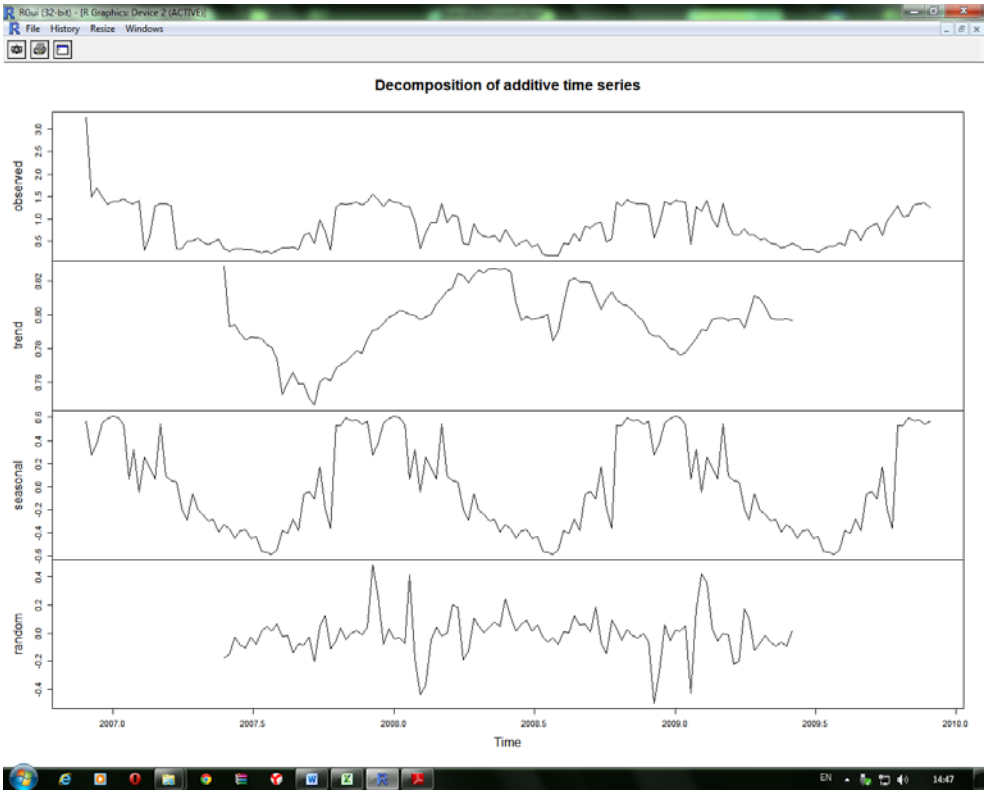

Fig. 2. Visualization of the decomposition of the additive time-series object with respect to the week period

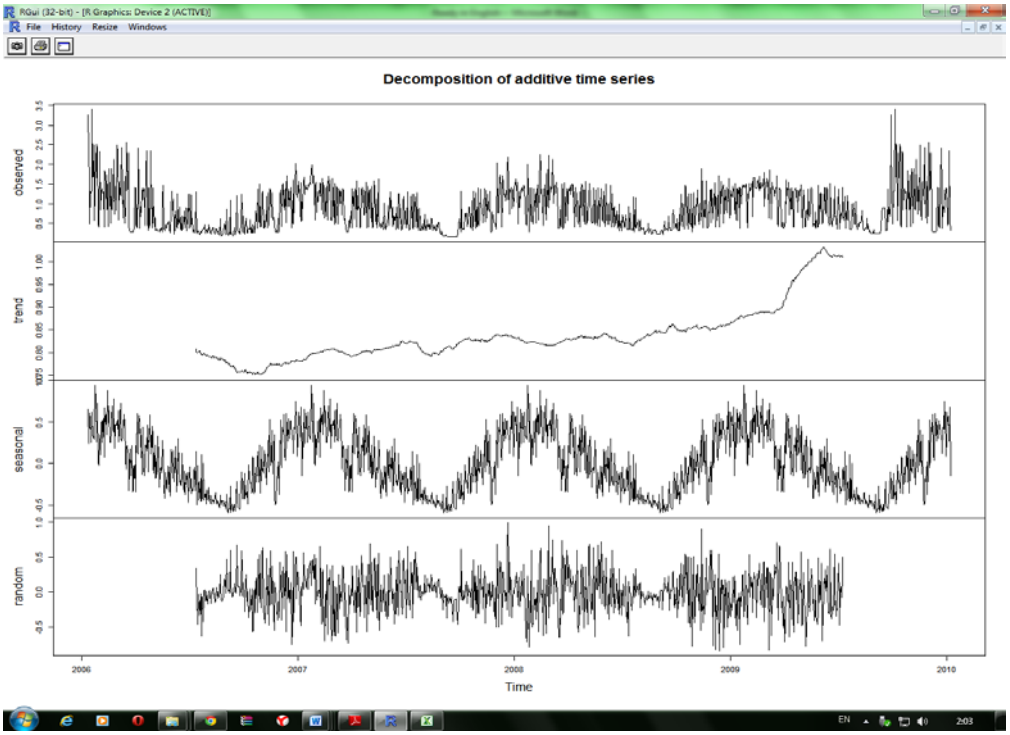

Fig. 3. Visualization of the decomposition of the additive time-series object with respect to the day period

The result of the dividing the data into components shows that time-series object is composed of trend, seasonal and irregular component. The graphics clearly shows that the

amplitude of both the seasonal and irregular variations do not change as the level of the trend rises or falls. It means our data is additive and the observed time series (O_t) is the sum of three independent components: the seasonal (S_t), the trend (T_t) and the irregular (I_t): $O_t = S_t + T_t + I_t$.

Choosing and fitting the model

Next step is to determine the appropriate model that fits the data. For that purpose we use Box and Jenkins approach [6] that allows selecting from a group of forecasting models the one that is the best to fit the time series data. The ARIMA (autoregressive integrated moving average) modeling can be applied to the most types of time series data. The forecasting accuracy of ARIMA model is considered by scientist to be of a high degree.

In R environment there is a function that allows automatically detect the best fitted model to the given time-series with the smallest values of the Akaike's information criteria (AIC). The output of (auto.arima) for week`s period is ARIMA(2,0,1)(1,0,1), for day`s demand is ARIMA(2,1,1).

Forecating

The forecasting is done for the autumn months of the year 2010 to understend the degree of accuracy that gives us the fitted ARIMAmodels for weeks and days periods.

The results of the prediction with respect to week`s period are presented at the figure 4.

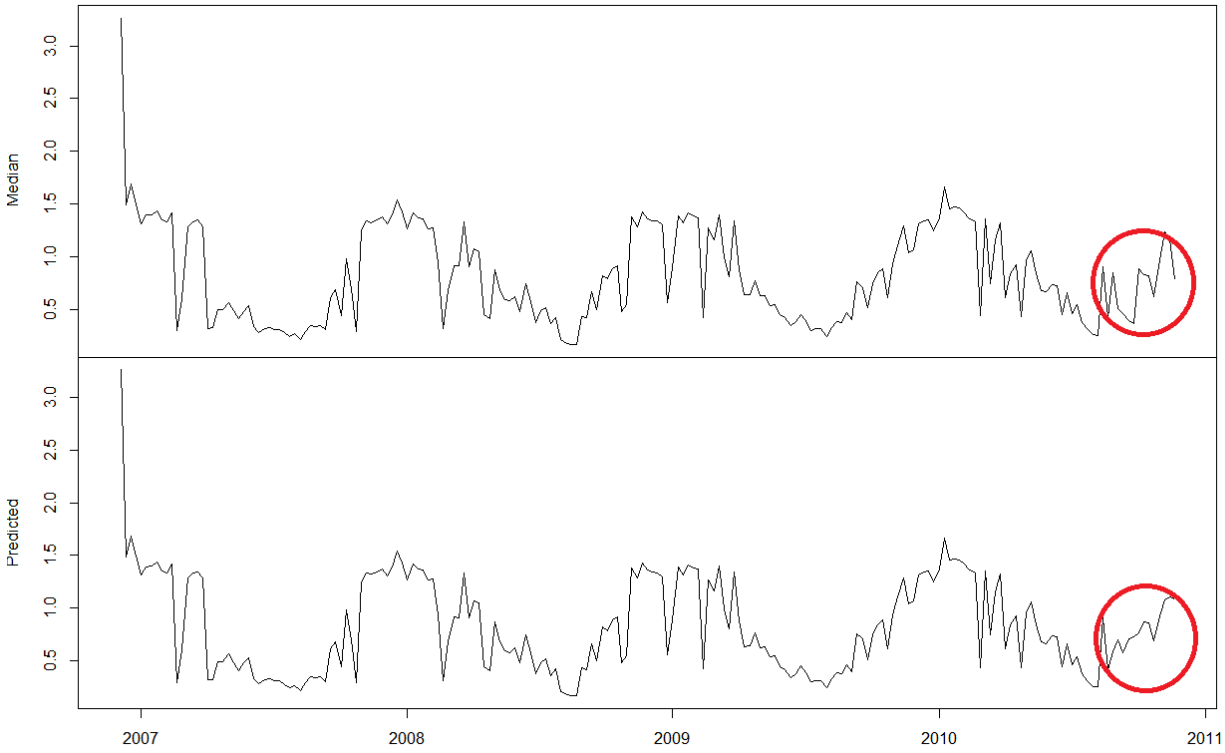

Fig. 4. Visualization of the forecasting of time-series data for autumn period 2010 with respect to weeks demand of electrical power consumption

Evaluation

Evaluation was made using the mean squared error (MSE) by calculating the difference between the forecasted values and the true values of the parameter with the following formula:

$$\mathrm{MSE}\,(\bar{y}_i y_i) = \frac{1}{n_{samples}} \sum_{i=0}^{n_{samples}-1} (y_i - \bar{y}_i)^2$$

The accuracy of the forecast with respect to week period is 0,039 and 0,201 for the day period. These results represent the high accuracy of the forecast. This proves the assurance of scientists that forecasting accuracy of ARIMA model is normally of a high degree.

Conclusion

The result of the research is the received forecast of the time-series data that is the day and week values of active power within individual household of a high degree of accuracy.

The results of the research can be applied in different fields. For example, knowing the amounts of energy consumption is of great importance for several reasons. First of all for consumers of electrical energy knowledge about the electric load and the targeted is important for understanding their bills and better controlling their consumption [7, 8]. For organizations it is also useful to know periods of minimum and maximum of the consumption for planning the technological cycles, for planning budget costs.

Secondly analyzing the data of energy consumption is useful for in energy sales companies to predict probable future consumption and applying the costs for electrical units on the opt market of electrical energy [9].

Thirdly it is useful for power grid companies to regulate and determine the optimal loading of transformer substations [10]. And at last analyzing the consumption of electrical consumption can be applied in governmental sector for calculating the optimal tariff schemes for different groups of consumers.

References:

1. UCI Machine Learning Repository http: //archive.ics.uci.edu /ml/datasets/Individual+household+electric+power+consumption;

2. Site TuTiempo: http://www.tutiempo.net/en/Climate/France/FR_3.html;

3. Bryan Nolan “Data Analysis: An Introduction”, Wiley, 1994;

4. J.S. Armstrong “Principles of Forecasting: A Handbook for Researchers and Practitioners”, Springer, 2001;

5. For R a-little-book-of-r-for-time-series: https://media.readthedocs.org /pdf/a-little-book-of-r-for-time-series/latest/a-little-book-of-r-for-time-series.pdf;

6. Rob J Hyndman, article “Box-Jenkins modeling”, 2001: http://robjhyndman. com/ papers/BoxJenkins.pdf.

7. Beliaeva N., Beliaev A., Petrochenkov A. Design and rationale of the algorithm of automated management of selected energy saving equipment for “Perm wooden house” // Solutions of applied problems in control, data processing and data analysis: 2nd International Conference of young scientists (4 April, 2011 Koethen, Germany). – Perm, Perm State Technical University Publishing house, 2011. P.3-13.

8. Beliaeva N., Beliaev A., Petrochenkov A. Energy saving controlling system for «PERM WOODEN HOUSE» // Innovation Technologies: Theory, Instruments, Practice: Proceedings oft he 3rd International Conference of young scientists and students. – Perm, 2012. – pp.329-338. – URL: http://conference.msa.pstu.ru/arhiv/skachat-sbornik-innotech-2011/view.

9. Kazantsev V.P., Petrochenkov A.B., Romodin A.V., Khoroshev N.I. Some aspects of Technology of Use of Electrical Objects on the Basis of Methods of Short Term Forecasting of Technical Condition. Russian Electrical Engineering, 2011, Vol. 82, No.11., pp.600-606, available at: http://link.springer.com/content/pdf/10.3103%2FS1068371211110058 (**DOI: 10.3103 /S1068371211110058**).

10. Petrochenkov A.B., Bochkarev S.V., Romodin A.V., Eltyshev D.K. The Planning Operation Process of Electrotechnical Equipment Using the Markov Process. Russian Electrical Engineering, 2011, Vol. 82, No.11., pp.592-595, available at: http://link.springer.com/content/pdf/10.3103%2FS1068371211110113 (**DOI: 10.3103/S1068371211110113**).

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Development of Gas Turbine Fast Mathematical Model Simulation Module for Software Complex «Electrodin» based on LabVIEW*

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Abstract. A fast mathematical model simulation module based on LabVIEW graphical programming environment has been developed. The module will be used for gas turbine and electrical power system co-simulation, and for testing automation of gas turbine automatic control systems.

Keywords: computer simulation; gas turbine; automatic control system; electrical power system; fast mathematical model; LabVIEW.

Introduction

Nowadays there is a growing demand for highly efficient gas turbines units (GTU) in energy and oil and gas industries to achieve economic efficiency and low environmental impact. A gas turbine engine is used in a broad scope of applications including electric power generation (to drive an electric generator), natural gas transmission (to drive pumps and compressors), and various process applications. The main advantages of modern gas turbines include compact size, ecological compatibility, relatively low capital investment, ability to work in cogeneration and trigeneration modes.

This work was carried out within the framework of the project which purpose was to create a multi-adaptive ecological test rig for gas turbines up to 40 MW for such objects as gas pumping units (GPU) and gas turbine power plants. The main goal was to increase GTU and GPU testing efficiency by development of the fast mathematical model simulation module based on LabVIEW

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for gas turbine, gas turbine automatic control system (ACS) and electrical power system co-simulation.

Automation of Gas Turbine Testing

The current situation in the field of GTU test automation is undergoing a lot of changes due to the expansion of their range of use, and, therefore, with the constant increase in the requirements for their operation and function. The specifics of GTU operation in new conditions as the drive for electric generator requires formation of new control algorithms, as well as conduction of research to reveal the impact on the quality of the transient processes during various modes of operation of the power plant, which includes gas turbines.

Also, there is significant progress in the development of software and hardware for automation devices, computing techniques, and information technologies. This provides the basis for GTU testing process modernization.

There are three types of GTU testing:

1) computer simulation;
2) semi-realistic simulation;
3) full-scale testing.

Let us consider the existing technology of GTU testing [1].

At first, tests are conducted on a computer (computer simulation), where hardware is simulated by mathematical models.

After that GTU software is checked by semi-realistic simulation using the microprocessors supplied by the developers and suppliers of hardware. Computer based model of GTU integrates with full-scale control equipment. Semi-realistic simulation enables to study control system functioning, and to assess the effectiveness of a complex control system in conditions as close to real as possible.

After the successful completion of the previous steps full-scale tests are carried out. Fully equipped gas turbine pilot unit is placed on a special testing rig for its trial in various modes of operation. GTU loading is carried out by a hydraulic brake, load of the field of active resistance or a power generator.

It should be noted that gas turbine operates only in the presence of ACS, which is a combination of a GTU and control devices. ACS is designed to perform the functions of control, monitoring and protection, ensuring long trouble-free operation of the unit. The controller contains ACS algorithms, which control the operation of gas turbine in various modes. Therefore, gas turbine testing is accompanied by gas turbine ACS testing.

Usually, when full-scale GTU ACS test begins parameters and control algorithms are already chosen by the developer of ACS. However, there is possibility to adjust the control algorithm by changing the preset ratios within a limited range. Adjustment is performed for each GTU separately and its results accompany the unit throughout its life cycle. Therefore, adjustment operation of ACS is essential for achieving high operational performance of GTU ACS.

Types of GTU tests mentioned above differ in the cost of research and in the possibilities of technical equipment, and mainly in the creation of conditions and ranges of factors influence that determine the functioning of GTU.

Practice shows that GTU testing types differ little in the possibilities of obtaining reliable characteristics of gas turbines, thus the amount of work and testing costs can be reduced for semi-realistic simulation and full-scale tests on the tasks that have been confirmed by computer simulation.

The benefits of computer and semi-realistic simulation are:

1) ability to reproduce the entire set of subcritical modes;
2) economic efficiency (fuel economy, lower material costs and cost by time);
3) flexibility of testing programs (possibility of conducting a large number of different testing programs);
4) ample opportunities for processing test results;
5) absence of risk of process upsets and equipment damage due to improper control commands.

Ample opportunities are provided in the application of combination of semi-realistic simulation and full-scale tests of ACS. This allows to make a system of mutually-complementary

tests, where ACS setting will be made during semi-realistic simulation, and the final ACS adjustment will be made during full-scale tests.

It should be noted that one of the main disadvantages of existing GTU testing technology is the lack of information about electrical power system operation modes in which GTU should operate. Tests with electrical power system are fulfilled only in part by full-scale tests on the testing rigs with limited functionality. The behavior of electrical load during the design stage, testing and adjustment of GTU ACS algorithms is important for GTU operating in the gas turbine power plant, therefore, information about electrical power system operation modes should be taken into account during computer and semi-realistic simulation of gas turbines.

Gas Turbine Computer Simulation

Overall, there are two classes of mathematical models used for GTU testing:

1) simplified mathematical models;
2) complete mathematical models (verification models).

Complete mathematical models are usually used in the last steps of GTU testing and simplified mathematical models are used for the calculation and modeling steps. Simplified mathematical models provide exact solution with the assumptions made. This solution can be used as a base for the implementation of the following steps.

GTU under consideration may consist of a large number of elements, so that even the use of modern computer technologies would require significant time for model calculation. Also, there are difficulties in conducting semi-realistic simulation, as it has more stringent requirements for models operation speed: models have to work at a pace of the real tested object.

Therefore, fast calculated mathematical models were used to configure ACS GTU algorithms, and for computer and semi-realistic testing of control algorithms. Fast mathematical models are built on the basis of simplified identification nonlinear models of gas turbines.

The main idea of fast mathematical models is to combine the linear dynamic model and nonlinear static characteristics of GTU. This type of mathematical models can ensure accuracy in the range of 2 - 5 % [2] and provides significant calculation time savings.

Fast mathematical models can be obtained by measuring the operating parameters of a full-scale GTU which is designed for use in a gas turbine power plant or GPU. Results of simulation with nonlinear dynamic GTU model can be used instead of the data from the full-scale gas turbine when debugging identification algorithms and before transferring algorithms to the real object.

The following fast mathematical models were implemented in this work:

1) linear gas turbine unit model;
2) nonlinear gas turbine unit model;
3) nonlinear gas pumping unit model;
4) nonlinear Capstone microturbine model (Capstone C-30);
5) electrical power system model;
6) gas turbine automatic control system model.

Below is a mathematical description of one of the GTU models.

Nonlinear Gas Pumping Unit Model

Fast mathematical model is designed to provide gas pumping unit control systems adjustment procedure. The model takes into account the accumulation of energy in the rotating mass of the two-shaft gas turbine rotor.

$$\dot{A}_{DI} = \frac{(A_{DIZ} - A_{DI})}{T_{DI}}, \quad (1)$$

$$G_{TS} = f(A_{DI}), \quad (2)$$

$$\dot{G}_T = \frac{(G_{TS} - G_T)}{T_{GT}}, \quad (3)$$

$$n_{TS} = f(G_T), \quad (4)$$

$$\dot{n}_{TK} = \frac{(n_{TS} - n_{TK})}{T_{NTK}}, \quad (5)$$

$$N_E = f(n_{TK}), \quad (6)$$

$$n_{CTZ} = f(N_E), \quad (7)$$

$$\dot{n_{CT}} = \frac{(n_{CTZ} - n_{CT})}{T_{NCT} \cdot n_{CT}}, \quad (8)$$

where A_{DIZ} is specified gas regulator rotation angle, A_{DI} is gas regulator rotation angle, G_T is fuel consumption, G_{TS} is fuel consumption based on the static characteristic, n_{TS} is compressor rotor speed based on the static characteristic, n_{TK} is compressor rotor speed, N_E is available power of free power turbine, n_{CT} is free power turbine rotor speed, n_{CTZ} is free power turbine rotor speed based on the static characteristic, n_{CT} is free power turbine rotor speed, T_{DI} is gas regulator time constant, T_{GT} is fuel consumption time constant, T_{NTK} is compressor rotor time constant, T_{NCT} is free power turbine rotor time constant.

Electrical Power System Model

Fast mathematical model of electrical power system can be implemented in two versions: fast mathematical model of the entire power system; fast mathematical model of an element or a subsystem of electrical power system. This provides the necessary flexibility.

The main disturbance from electrical power system is the active power which is converted into mechanical power on the shaft of gas turbine. In the case of multiply connected systems, it is required to take into account the voltage changing at the nodal points of electrical power system. Therefore, fast mathematical models used for simulation are considered relative to the active power and voltage. The scheme of the model is shown in Figure 1 where SG is synchronous generator, AFR&E is automatic field regulator and exciter [4].

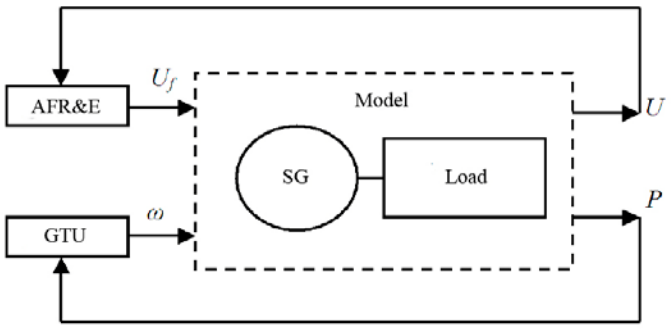

Fig. 1. The scheme of the fast mathematical model which is considered relative to the active power and voltage

Electrical power system model is as follows [2]:

$$\mathbf{V}(k+1) = \mathbf{A}\mathbf{V}(k), \quad (9)$$

where **V**(k) is the extended state vector for k moment, **V**(k+1) is the extended state vector for (k+1) moment, **A** is the transition matrix from state at k moment to the new state at (k +1) moment.

Since electrical power system is a nonlinear object with structurally complex model sometimes it is necessary to use several matrices **A** or a matrix **A** with variable parameters which are functions of the operating mode and operating parameters [1].

In the used model of electrical power system the following operational parameters are taken into consideration: load power, generator rotation frequency, generator voltage, generator excitation voltage, generator current and generator field current. These parameters are written in the state vector of the system **V**.

Gas Turbine Automatic Control System Model

Automatic control system of fuel regulator has a complex structure. Therefore, in this work, free power turbine speed stabilization loop is considered to simplify this problem. This loop is basic and it defines free power turbine speed error by set point.

Real-life GTU free power turbine speed regulator is taken as a basis. The linearized simplified regulator structure is shown in Figure 2.

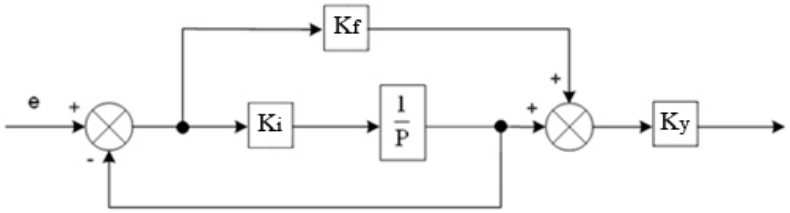

Fig. 2. Regulator schematic diagram

Aperiodic link of the regulator is formed by the coverage of the integrator by negative feedback. Forcing link of the regulator is formed by parallel chains of the integrator and a chain with a forcing component gain K_f.

In real regulators all parameters $\mathbf{K} = (K_i, K_y, K_f)^T$ are the functions of GTU operating mode because it is necessary to take into account the nonlinearity of the control object.

The difference between the setpoint and the actual value of the free power turbine speed is determined by the formula (10).

$$e = n_{ст}^{stpnt} - n_{ст}. \quad (10)$$

Regulator transfer function is as follows:

$$W(p) = e \cdot \left(\frac{1}{T_i \cdot p + 1} + K_f\right) \cdot K_y, \quad (11)$$

where $T_i = \frac{1}{K_i}$; K_f is forcing component of free power turbine loop gain; K_y is free power turbine loop gain; K_i is integral component of free power turbine loop gain.

Software Complex "ElectroDin" for Gas Turbine Unit and Gas Turbine Unit Automatic Control System Testing

Software complex "ElectroDin" is used to make fast mathematical models. It is written in the Java programming language [5, 6].

Software complex "ElectroDin" is designed for gas turbine testing, for GTU ACS adjustment and testing on a simulation multimode dynamic model of electrical power system, for steady and transient state calculation and for calculation of processes in electrical power system of any structure, as well as for GTU models identification.

To obtain the desired gas turbine mathematical model required parameters selection is carried out for model identification based on experimental data. After that, mathematical model identification is performed and mathematical model adequacy is checked. The obtained model parameters are stored in a XML file format. The results of gas turbine identification are coefficient values of differential equations of the model and static characteristics.

Module for complete electrical power system mathematical model simulation is designed for reproduction of dynamic operation modes on the mathematical model to solve problems of analysis which involve process calculation (electromagnetic, mechanical, etc.) in a given electrical power system. Electrical power system has a predetermined structure and characteristics of all its elements.

Mathematical model of electrical power system consists of two interrelated components: model of individual elements and their interaction model.

Universality of algorithms for computing is achieved by presenting all models of the elements in a single generalized form:

1) the mathematical model of each structural element is represented in the Park-Gorev coordinates and is written in the form of a system of differential equations;

2) the mathematical models of elements are transformed to a single generalized matrix-vector form.

For steady state matrix-vector equation is as follows [7]:

$$\mathbf{U} = \pm\mathbf{A} \times \mathbf{I} + \mathbf{E}, \quad (12)$$

where **U** is terminal voltage column matrix for *d*, *q* axes; **A** is resistance of the element matrix for *d*, *q* axes; **I** is current of the element column matrix for *d*, *q* axes; **E** is voltage source of the element column matrix for *d*, *q* axes.

For transient state matrix-vector equation is as follows [7]:

$$p\mathbf{I} = \pm\mathbf{A}\mathbf{U} - \mathbf{B}\mathbf{I} - \mathbf{H}, \quad (13)$$

where p**I**, **I** are current vector and vector of current derivatives of the element; **U** is vector of voltage applied between the external terminals of the element; **A**, **B** are matrices which dimension depends on the coordinate system in which the structural element is simulated, also it depends on the equation form (full form or simplified form); **H** is vector which determines the impact of electrical parameters control means on the element; *p* is symbol of differentiation.

For electrical power system parameters calculation node voltage method is applied. Node voltages are found from the following system of equations [7]:

$$\boldsymbol{Y} \times \boldsymbol{U} = \boldsymbol{J}, \quad (14)$$

where **Y** is block matrix of known nodal conductivity; **U** is block-column matrix of nodal voltages; **J** is block-column matrix of known setting currents.

Defined nodal voltages are used to calculate currents for each of the elements. After that, all other parameters are calculated.

Fast mathematical model of electrical power system is a separate mode of software complex "ElectroDin". It is used for automatic adjustment of GTU ACS. To construct the fast mathematical model of electrical power system arrays of experimental data of established transient state are used. In this case the presence of array of an active power and generator speed is required. Moreover, the more additional variables are in the experimental data, the more accurate model is obtained. Additional variables can be taken from different elements of electrical power system.

To obtain the required fast mathematical model of electrical power system simulation of the desired mode on the full model is performed. Then the obtained dependencies of the parameters from the transient state time are stored. After that, selection of the main parameters of the structural elements which have most influence on the mode process is performed. Then these parameters (time, active power of the generator, generator speed, etc.) are collected in one file. Fast mathematical model is created by running the module for fast mathematical model construction where the model is identified and checked.

The output of the fast mathematical model module is:

1) the coefficient matrix of the model in the state space;
2) the state vector of the initial steady state;
3) the state vector of the beginning of the transition process.

The obtained model of electrical power system is written in the CSV file which data is used for GTU load model.

Structure of the software complex "ElectroDin" is shown in Figure 3.

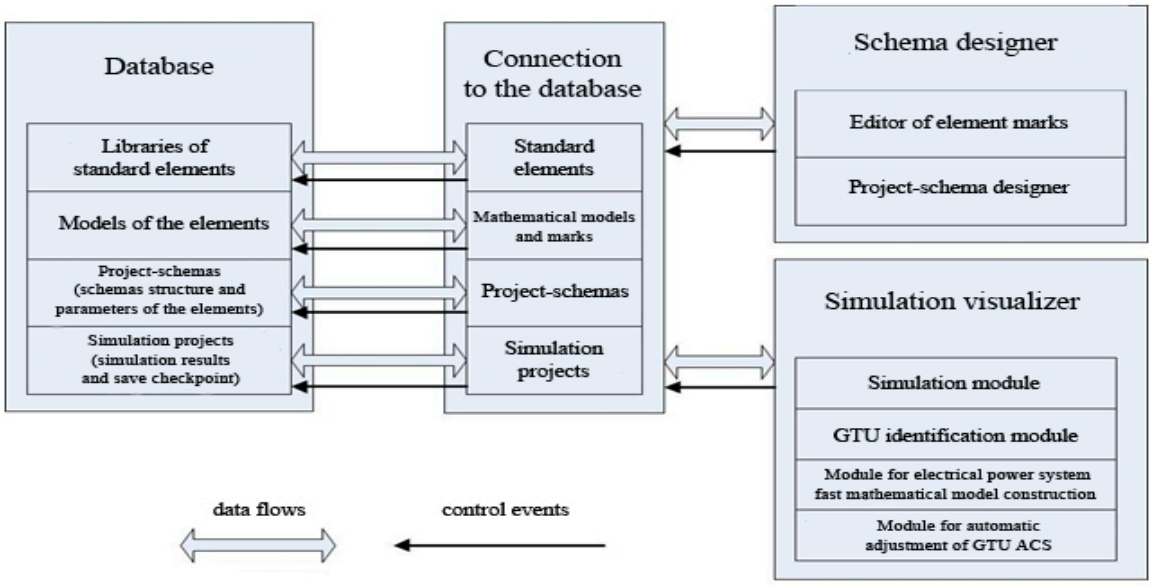

Fig. 3. Structure of the software complex "ElectroDin" and relationship between its components

Since the software complex "ElectroDin" is unable to work in real time it was necessary to create an additional simulation module using tools which enable to solve this problem.

Simulation Module for Software Complex «ElectroDin» based on LabVIEW

When creating specialized software the need to choose one of the following ways arises:

1) the use of traditional programming tools (traditional programming languages, standard debugging tools, etc.);

2) the use of existing development tools best suited to achieve the objectives and requirements which are imposed for software.

The most important tasks are as follows: reducing the time and cost of software development; minimizing the complexity associated with debugging and simulation of mathematical algorithms that are needed to obtain intermediate and final results and measurements.

For complex distributed systems development process of their own software using traditional programming tools may become too time-consuming and costly. This way is suitable mainly for simple systems or elements of a larger system for which there are no standard solutions or these solutions are not satisfied for some reason or other.

When some specific software development environment is selected, it must meet all the requirements which are imposed for the programming language and support all modern standard communication protocols, and also, it must have high compatibility with other programming languages.

In our case, the second way was preferred, as it was required to minimize the time needed to develop a module, to debug it and to simulate mathematical algorithms. Also, it was required to provide the ability to support standard communication protocols and to achieve a high compatibility with other programming languages and hardware.

In this work, LabVIEW graphical programming environment was chosen for module development. Selection of LabVIEW as a mean of module implementation is due to the fact that this environment is used in automation testing rigs of Perm engine company [8]. Also, choice of LabVIEW is explained by the following reasons:

1) **environment provides the requirement of cross-platform;**

2) **environment provides high performance by enabling data acquisition and data processing in real time and by enabling testing in parallel mode;**

3) **environment provides flexibility and extensibility of developed applications by using the concept of modular programming;**

4) **environment provides accuracy of the calculations.**

The basis of National Instruments measurement and control systems is the concept of virtual instruments (VIs) which are the measurement tools built on the basis of computer technology, data

acquisition boards and software for data acquisition and processing [9]. As the functionality of virtual instruments is programmed by the user, they are extremely flexible and efficient.

Description of Simulation Module

As it was said before, following fast mathematical models which were obtained using software complex "ElectroDin" were implemented in the module based on LabVIEW: linear and nonlinear GTU models, nonlinear gas pumping unit model, nonlinear Capstone microturbine model, electrical power system model, and gas turbine ACS model.

Parameters of specified fast mathematical models are obtained using software complex "ElectroDin", and then put in a simulation module based on LabVIEW via CSV and XML file formats. The result of modeling is a set of basic parameters dependencies from the time of transient state.

Figure 4 shows the connection between software complex "ElectroDin" and module based on LabVIEW.

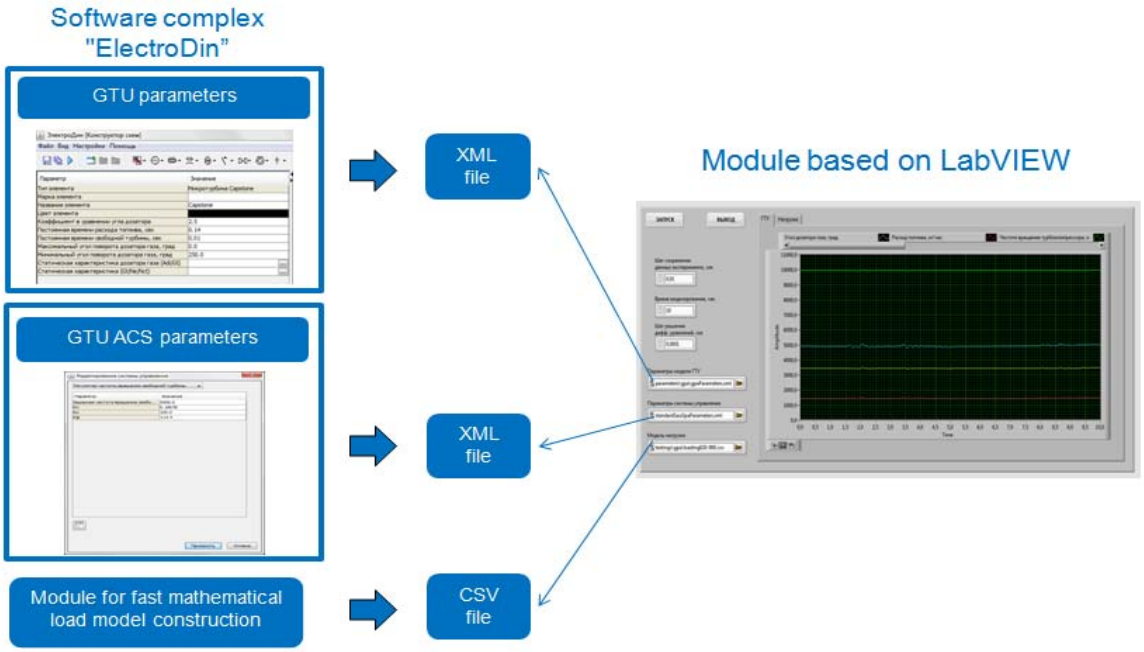

Fig. 4. Connection between software complex "ElectroDin" and module based on LabVIEW.

Front panel of the module is shown in Figure 5.

Simulation settings of the module include:

1) data saving step time is the interval with which the module saves parameters and displays them in the form of graphs after simulation has ended. Data saving step time affects the accuracy of the display of the parameters;

2) simulation time is the total simulation time;

3) step time of differential equations solving is the interval with which module solves differential equations. This parameter affects the accuracy of the transient state calculation.

Initial parameters which were obtained using software complex "ElectroDin" include:

1) GTU model parameters (XML file with values of coefficients and constants of GTU, and static characteristics);

2) GTU ACS parameters (XML file with values of coefficients of GTU ACS, and static characteristics);

3) Load model (CSV file with values of parameters and coefficients of electrical power system).

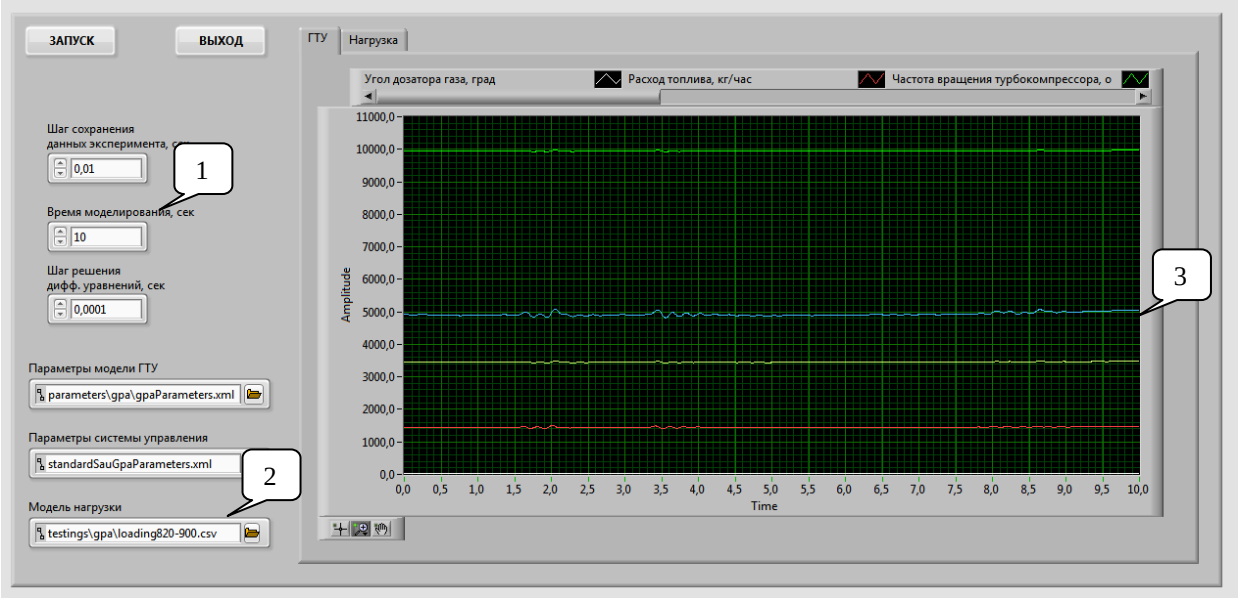

Fig. 5. Front panel of the simulation module based on LabVIEW:
1 – simulation settings; 2 – files with the initial parameters of GTU,
GTU ACS and load models; 3 – dependencies of main mathematical model
parameters from the time of the transient state

The module is based on the concept of modular programming. A large problem was divided into a series of simple subtasks. Then VIs to perform each of the subtasks were created, and combined on the Block Diagram of higher level application which performs the task as a whole.

The advantage of modular programming technology is the ability to work with each SubVI separately making it easier to debug the module as a whole. Besides some SubVIs of a low level often perform tasks that are typical for several SubVIs of a higher level, and therefore can be used independently a lot of times.

The project includes thirty main VIs and SubVIs. On the basis of the set of interchangeable VIs the user can write his own GTU models, load models (electrical power system models) and GTU ACS models.

Description of the Modeling Order

The module consists of two subprograms:

1) subprogram for testing GTU model without GTU ACS;

2) subprogram for testing GTU model with GTU ACS.

The simulation runs as follows*:*

1) place required GTU model into corresponding directory;

2) launch simulation subprogram;

3) select files with initial parameters of GTU, GTU ACS and load models;

4) select data saving step time, simulation time and step time of differential equations solving;

5) start the simulation by clicking "Запуск" ("Start") button.

After the simulation, the right pane displays the dependencies of the main GTU parameters and load parameters from the time of the transient state. It is possible to record the parameters values in XLS file.

Figure 6 shows general algorithm of the module for gas turbine, gas turbine ACS and electrical power system co-simulation ,where T_s is the simulation time and T_{de} is the step time of differential equations solving.

As it can be seen from Figure 6, mathematical modeling is divided into two classes:

1) mathematical models for steady state calculation (static mode calculation);

2) mathematical models for transient state calculation (dynamic mode calculation).

The main task of the developed module is reproduction of dynamic modes of GTU operation on mathematical model for the purpose of making an investigation and GTU control. But transient

processes start with prior steady states, therefore, static mode should be calculated first, and then the dynamic mode.

The interaction between mathematical models of GTU, GTU ACS and electrical power system is carried out due to the transmission of parameters such as power consumption, gas regulator rotation angle, free power turbine rotor speed.

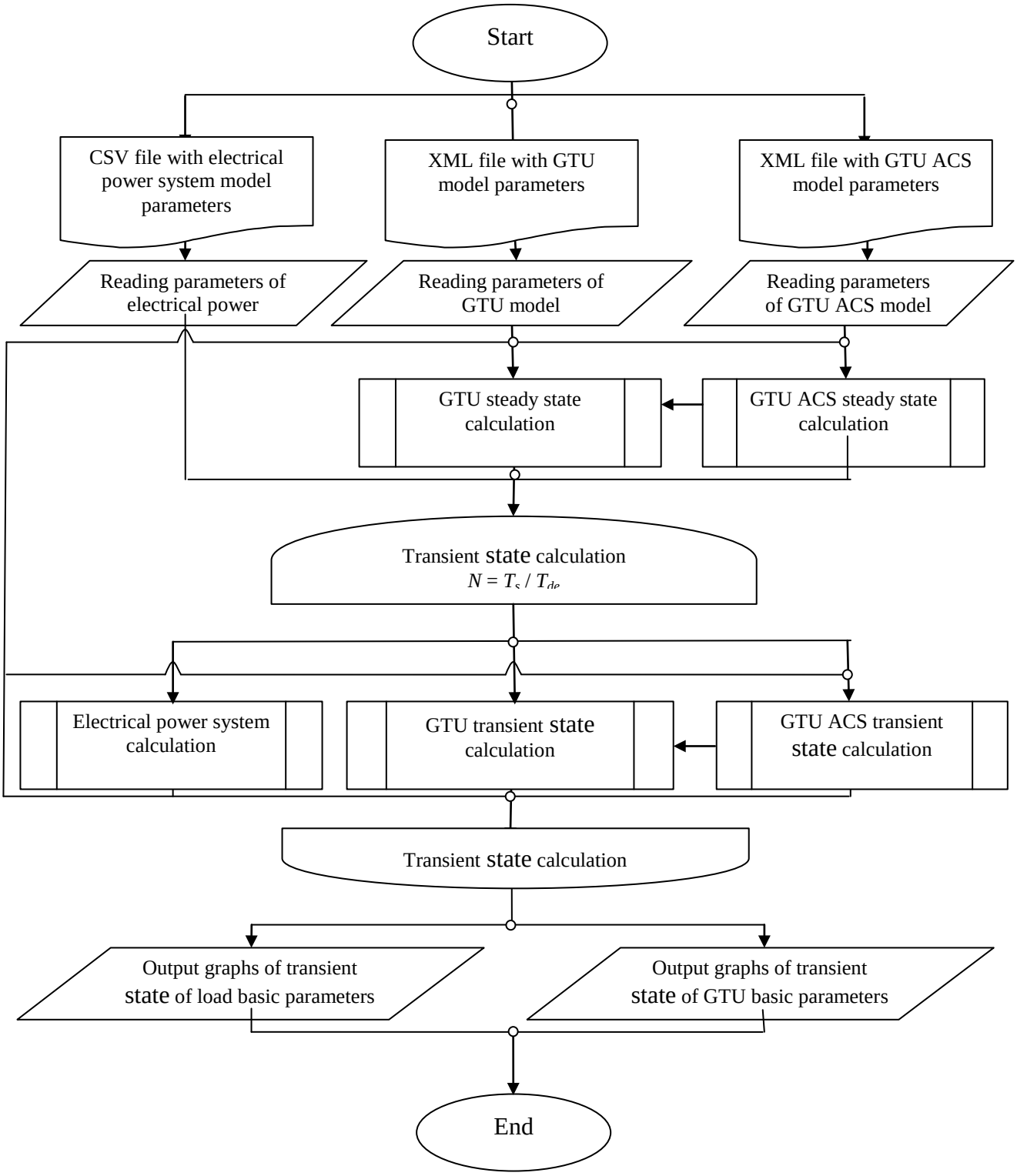

Fig. 6. The algorithm of gas turbine, gas turbine automatic control system and electrical power system co-simulation

Results and Discussion

In this study, assessment of the quality and accuracy of the gas turbine simulation was performed by using the Theil uncertainty coefficient: implemented fast mathematical models were evaluated by comparing simulation results with sets of experimental data obtained in real gas turbine testing.

Theil uncertainty coefficient U measures the degree of discrepancy between the values of the generalized process parameter determined experimentally and the values of the generalized process parameter determined by calculation according to the model [10, 11].

$$U_1 = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{n}\left(x_i^{(e)} - x_i^{(m)}\right)^2}}{\sqrt{\frac{1}{N}\sum_{i=1}^{n}\left(x_i^{(e)}\right)^2} + \sqrt{\frac{1}{N}\sum_{i=1}^{n}\left(x_i^{(m)}\right)^2}}, \quad (15)$$

where $x_i^{(e)}$ is experimental value, $x_i^{(m)}$ is the value calculated by the functional model, n is the number of experimental values which were used for the model synthesis.

The values of the Theil uncertainty coefficient belong to the interval [0,1]. Ends of the interval have the following interpretation: if the Theil coefficient is U = 0 then we have a perfect fit; if the Theil coefficient is U = 1 then model is inadequate [12].

Acceptable error of the model is determined by the error of measuring instruments. The model must have an error of no more than 1-2% [4].

Figure 7 shows dependencies of fuel consumption G_T from the time of the transient state, compressor rotor speed n_{TK} from the time of the transient state, free power turbine rotor speed n_{CT} from the time of the transient state, gas regulator rotation angle A_{DI} from the time of the transient state, available power N_E from the time of the transient state which were obtained during step increase load simulation of gas pumping unit model. Figure 8 shows dependency of active power from the time of the transient state.

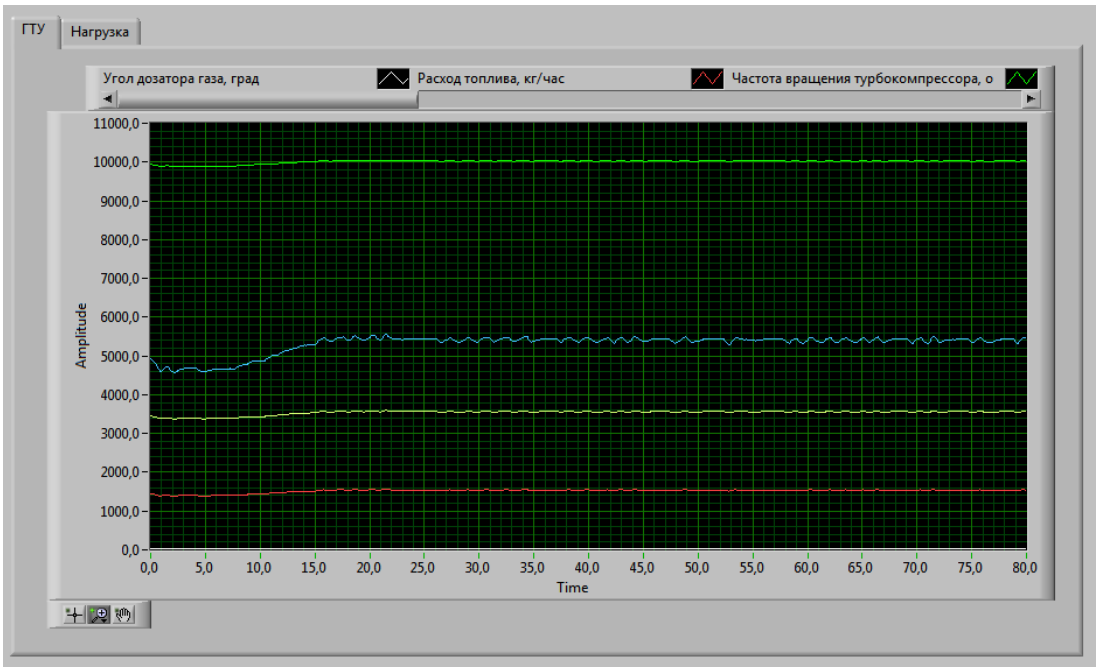

Fig. 7. Dependencies of G_T, n_{TK}, n_{CT}, A_{DI}, N_E from the time of the transient state which were obtained during step increase load simulation of gas pumping unit model

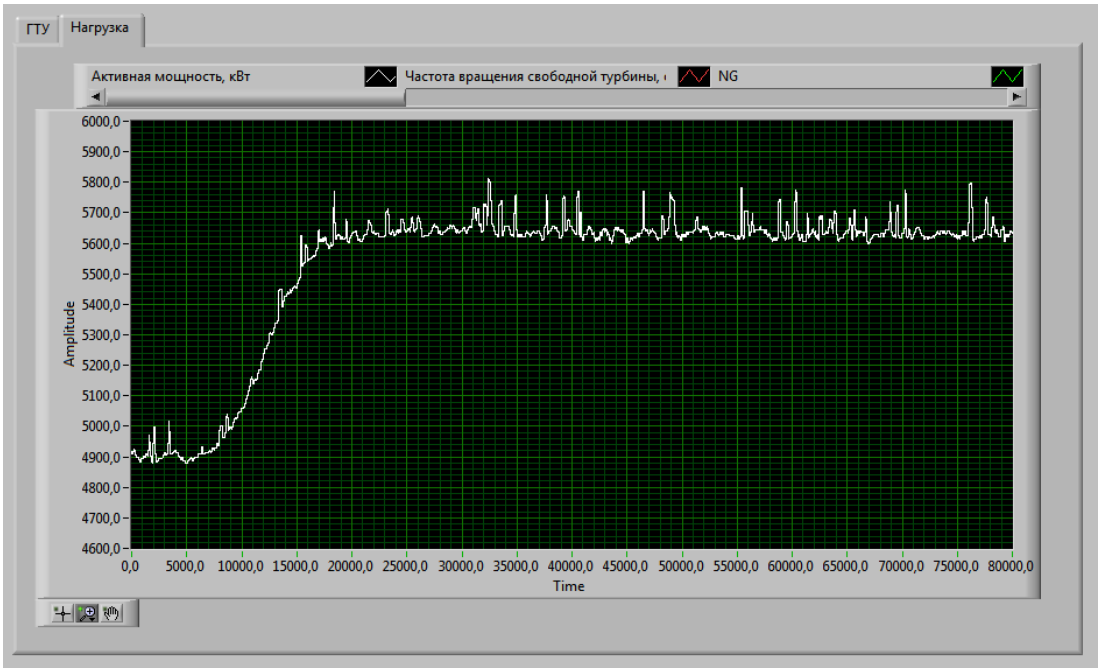

Fig. 8. Dependency of active power from the time of the transient state which was obtained during step increase load simulation of gas pumping unit model

Figures 9, 10 and 11 show dependencies of compressor rotor speed, free power turbine rotor speed and fuel consumption from the time of the transient state which were obtained experimentally and during simulation. The study was conducted by putting gas regulator rotation angle experimental values and load power experimental values to the gas pumping unit model input. The experimental data are given by the red line, whereas the blue line depicts the simulation data.

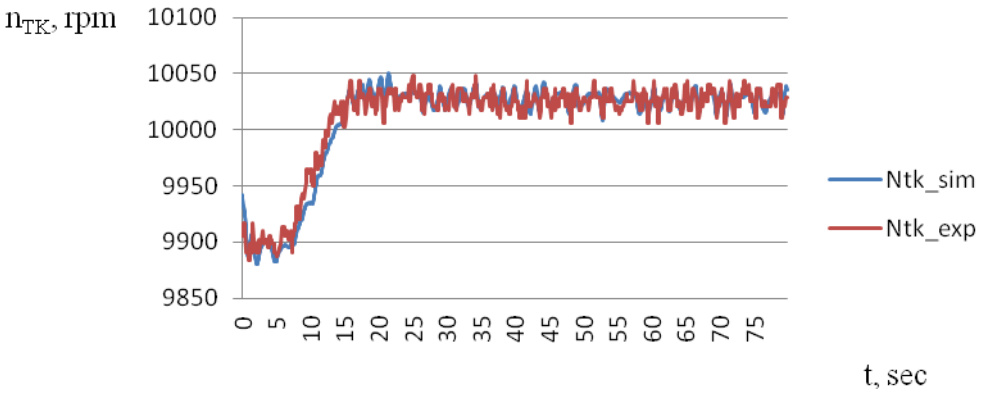

Fig. 9. Transient state of compressor rotor speed

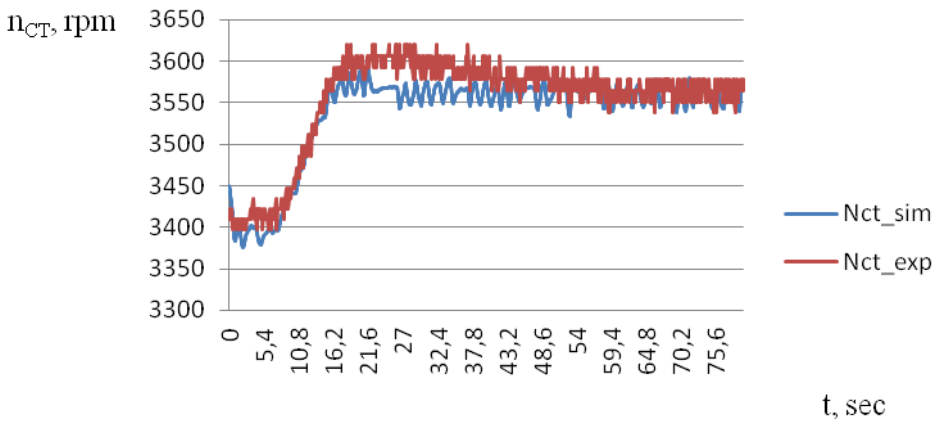

Fig. 10. Transient state of free power turbine rotor speed

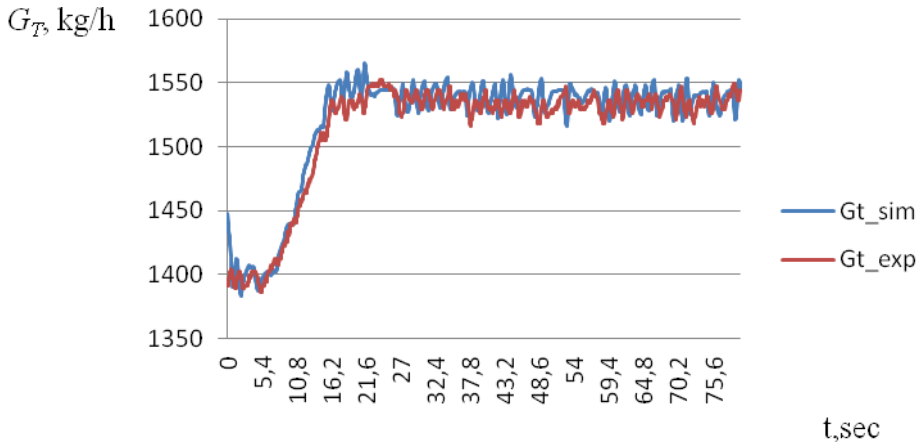

Fig. 11. Transient state of fuel consumption

The same comparison was done for step increase and step decrease load simulation of gas pumping unit model and nonlinear Capstone microturbine model. Table 1 shows the obtained values of Theil uncertainty coefficient for all tested fast mathematical models of GTU.

Table 1.

Values of Theil uncertainty coefficient

Tested model	U_{NTK}, %	U_{NCT}, %	U_{GT}, %
Nonlinear gas pumping unit model (step increase load)	0,05	0,3	0,4
Nonlinear gas pumping unit model (step decrease load)	0,04	0,5	0,4
Nonlinear Capstone microturbine model (step increase load)	-	0,3	2,2
Nonlinear Capstone microturbine model (step decrease load)	-	0,4	2

According to the results of Theil uncertainty coefficient calculation for basic compared parameters constructed fast mathematical models are reliable and have sufficient accuracy. Most of the values of Theil uncertainty coefficient does not exceed 1-2%.

Conclusion

Program module for gas turbine, gas turbine ACS and electrical power system co-simulation fully satisfies all requirements and performs all the necessary functionality.

Fast mathematical models which were implemented in the module can be used for diagnostic tasks, for configuration and optimization of gas turbine control systems during various GTU testing. This enables to expand the functionality of GTU testing, to reduce the time of preparation and testing, and thus to reduce the cost of development and commissioning of gas turbines.

In addition to the direct use of the developed module on test rigs, it is possible to use it in other research stands and automation systems, built on the basis of LabVIEW. Implemented GTUs fast mathematical models can be used as elements of power generation in the stands for computer and semi-realistic simulation of various types of energy networks based on LabVIEW for the energy network computer and semi-realistic simulation stands.

Reference:

1. Petrochenkov A. B., Kavalerov B. V., Shmidt I. A., Odin K. A., Tarasov V. A. Razrabotka metodologii i programmno-tekhnicheskikh sredstv intellektualizatsii yedinogo tsentra mnogotselevykh ispytaniy gazoturbinnykh ustanovok do 40 MV [Development of a methodology and software and hardware means of intellectualization of an integrated center for multipurpose testing of gas turbines up to 40 MW]. Perm: PNRPU, research progress report, 2012. (in Russian)

2. Kavalerov B. V., Kazantsev V. P., Shmidt I. A. Simulator and Semi-Nature Testing of Gas-Turbine Power Units Control Systems. *Information and Control Systems*, 2011, no. 4 (53), pp. 34-41. (in Russian)

3. Kilin G. A., Kavalerov B. V., Odin K. A. Identifikatsiya MT Capstone dlya modelnogo ispytaniya i nastroyki sistemy upravleniya [Identification of Capstone micro turbine for model testing and control system adjustment]. Perm, 2013. (in Russian)

4. Kavalerov B. V., Petrochenkov A. B., Odin K. A., Tarasov V. A. Modeling of the Interaction of Structural Elements. Russian Electrical Engineering, 2013, vol. 84, No. 1, pp. 9–13. available at: http://link.springer.com/article/10.3103/S1068371213010033
(**DOI: 10.3103/S1068371213010033**).

5. Petrochenkov A. B., Kavalerov B. V., Odin K. A., Arbuzov I. A., Shchenyatskiy D. V., Ryazanov A. N. "ElektroDin". Patent RF №2012660288, 2012, Rospatent.

6. Petrochenkov A. B., Kavalerov B. V., Odin K. A., Arbuzov I. A., Shchenyatskiy D. V., Ryazanov A. N. Baza dannykh ElektroDin ["ElektroDin" database]. Patent RF № 2012621177., 2012, Rospatent.

7. Vinokur V. M., Kavalerov B. V., Petrochenkov A. B., Sapunkov M. L. Matematicheskoye modelirovaniye gazoturbinnykh mini-elektrostantsiy i mini-energosistem [Mathematical modeling of gas turbine power plants and microgrids]. Perm: PNRPU publishing office, 2010. 299 p. (in Russian)

8. Vlasov V. G., Shchenyatskiy D. V. Perspectives of service development for oil and gas industry. 6 Mezhdunarodnaya nauchno-tekhnicheskaya konferentsiya "Razrabotka, proizvodstvo i ekspluatatsiya turbo-, elektronasosnykh agregatov i sistem na ikh osnove". Voronezh, 2009, 8 p.

9. Patrakeyev N. V., Potapov A. I., Makhov V. E. LabVIEW 8 – novyye vozmozhnosti avtomatizatsii proyektirovaniya kontrolno-izmeritelnykh sistem [New opportunities for design automation of measurement and control systems]. *Components & Technologies*, 2007, no. 2(67), pp. 138–141. (in Russian)

10. Ahlburg D. A. Forecast Evaluation and Improvement Using Theil's Decomposition. *Journal of Forecasting*, 1984, vol. 3, no. 3, pp. 345-351.

11. Semenychev V. K., Semenychev Ye.V. Parametricheskaya identifikatsiya ryadov dinamiki: struktury, modeli, evolyutsiya [Parametric identification of the time series: structures, models, evolution]. Samara: SSC RAS, 2011, 364 p. (in Russian)

12.Waterhouse S. Comparing and simulating travel time predictions from stationary and mobile sensors. Stockholm, 2011, 65 p.

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«Green» Energy Harvesting by Means of Piezoflexogeneration from Vibration or Similar Processes

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Abstract. The piezoelectric systems of electric energy harvesting with an adaptive low-frequency resonance are developed. These systems allowed to obtain electricity from low-frequency vibration. The availability of their application for adaptation to other periodic processes including pedestrians and vehicles movement is shown.

Keywords: Energy harvesting systems; piezogenerator; alternative energy; “green” electric energy from vibration.

Introduction. The modern advance in the sphere of energetics is taking place under conditions when conventional basic energy sources have been developed and the most large-scale resource associated with hydrocarbon raw materials is objectively restricted. As a result the search for new alternative energy sources and proper ways of their adaptation is of great interest. Therefore, the solutions oriented on new energy source adaptation that will allow obtaining practically “green” electric energy are especially important. Vibration is one of such sources. It follows various anthropogenic and natural processes and is lost being only an additional ecological load for the environment. However the question of considerable energy obtaining and harvesting from the most common low-force vibration all recent achievements in this sphere [1-5] taken into account is still under discussion.

Materials and Methods. The new energy harvesting system development and usage results are given in the article, piezoelectric transducers which generate electric charge under mechanical effect being applied. At present this is the way of obtaining electric energy in the number of mainstream devices (piezoelectric lighters, electroshocks, etc.) with ceramic piezoelements functioning in the direct “compression-stretching” mode. These piezoelements are also suggested for systems harvesting energy from moving vehicles [6]. However, while these

devices are operating, piezoelements undergo high mechanical and electrical loads. This lowers their functionality and hampers their applying in energy harvesting systems where they are supposed to function for long periods under such strict conditions. In addition, when using these element containing batteries a serious challenge is to synchronize separate elements' work by time and phase and to correlate the obtained voltages (kV) with outer electric circuits. The decrease of force impact on these ceramic piezoelectric elements up to order of units (N) force level leads to their piezogeneration effectiveness decrease so that it becomes impossible to gain electric energy from low-force vibration and similar processes.

We have developed new type active piezomaterials and highly effective transducers made on their base as well as created new energy harvesting systems where these transducers are applied [7-9].

We managed to increase piezogeneration effectiveness from low-force impacts, which allowed us to develop the functioning model producing electricity from vibration [10]. While solving this problem we proceeded from the fact that piezogeneration effectiveness, when a piezoelectric element was affected mechanically, is mainly determined by its piezoelectric constants, dielectric permittivity and elastic compliance. The function of two first properties is evident, because electric energy (W) generated by the piezoelectric element under the force (F) impact, for example, in its polarization coinciding direction, is determined by relation:

$$W = (d_{33} \cdot F)^2 / 2 \cdot C,$$

where d_{33} – longitudinal vibration piezoelectric constant and C – capacity linear to its dielectric permittivity.

The elastic compliance function is essentially different. It determines and limits the mechanical energy which piezoelectric element, when affected by force, accepts for transformation. This energy equals the product of the force affecting the piezoelement by its linear size change in the direction of this force impact. It is this size change that is determined by its elastic compliance.

Our solution is based on applying flexible piezoelements with high elastic compliance. Their linear size change as compared to that of ceramic elements which work in direct "compression-stretching" mode when affected by one and the same force is ten thousands of times more. It leads to proportional flexible element-generated electric energy increase (table 1) and allows obtaining ten thousands of times higher energy from comparatively weak mechanical effects. The open circuit voltage generated by these elements can be up to 30 V.

Table 1. The values of electrical energy generated by flexible piezoelectric element (new solution) and typical ceramic piezoelectric element operating in the direct "compression-stretching" mode (analogue)

Force, N	**One element energy, μJ**	
	New solution	**Analog**
1	**60**	**0.0015**
2	**120**	**0.0060**
3	**200**	**0.0135**
5	**205**	**0.0375**

According to Table 1, the energy generated by flexible piezoelectric elements (when force load grows) firstly increases in direct ratio and then practically remains invariable. This fact makes it reasonable to limit force impact level when the elements are used as energy generators. It is also important that this limitation level is significantly lower than force load values, maximum permissible for these piezoelectric elements. As a result, the used flexible element effective work conditions appear to be rather comfortable. The testing showed that if optimal work conditions are kept the elements do not lose their performances after $0{,}5 \times 10^9$ operations (the persistent running mode under conditions of energy generation from 50 Hz frequency vibration with 2.5 N force load for 120 days).

When flexible piezoelectric elements are used as energy generators there is one more important opportunity for their work optimization. It is connected with the fact that on the base of flexible piezoelectric elements it is possible to construct the mechanical schemes with the given low-frequency resonance. As it can be seen from fig.1 the vibration frequency adapted resonance systems allow significant energy generation effectiveness increasing.

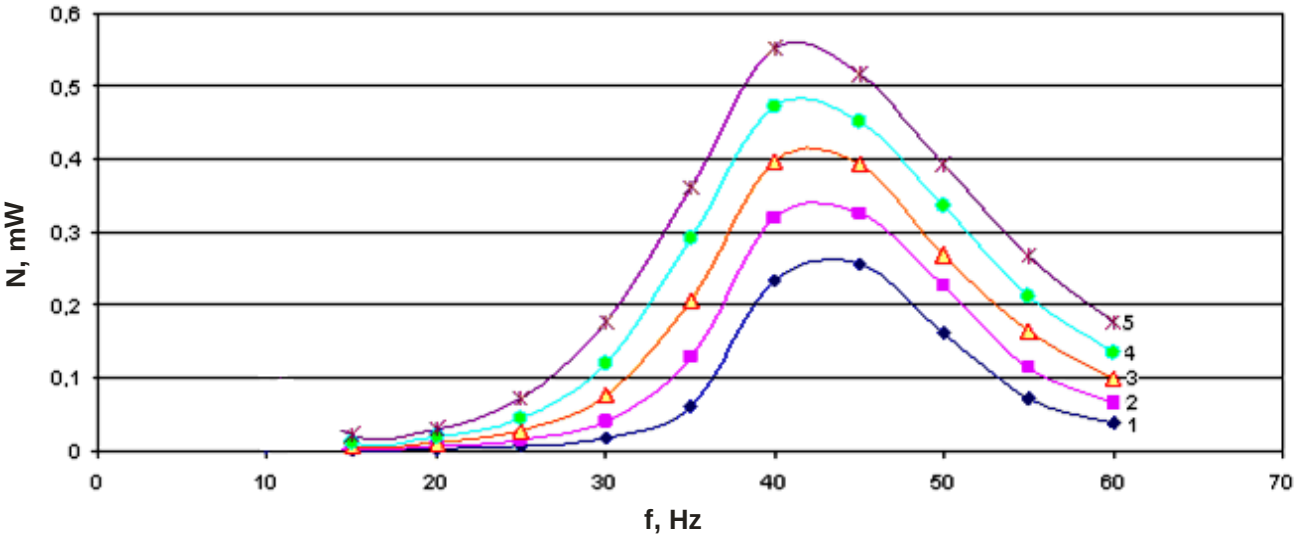

Fig. 1. The dependence of energy piezogeneration power obtained from flexible piezoelectric elements on vibration frequency and amplitude (curves 1; 2; 3; 4 and 5 correspond to vibration amplitude 0.3; 0.4; 0.5; 0.6 и 0.7 g respectively).

With regard to permissible force loads on flexible piezoelectric elements and their elastic properties the possible resonance system frequency is limited up to 100 Hz. This leads to new opportunities to obtain energy from new sources including various types of low-frequency natural and anthropogenic vibrations as well as similar processes.

Discussion. It is also important that the number of potentially prospective processes which can become the energy obtaining source with flexible piezoelectric element use include wave processes as well as periodic effects from pedestrian and vehicle movement. They can be also regarded as low-frequency vibration sources. Taking into account the limit for flexible piezoelectric element force impact permitted level to adapt these high-power sources we should develop multi-element energy harvesting systems where outer force impact is distributed among separate flexible piezoelectric elements and does not exceed their permitted values.

The example of such solution is a functioning five-element generator that we prepared [10] which develops power up to 3 mW when vibration is transformed with the frequency of 30 Hz, acceleration of 1g and general force load of 10 N.

Using the opportunity to create multiunit flexible element piezoelectric generators it is possible to drastically increase energy harvesting system power and provide adaptation of practically any mechanical loads.

It is noteworthy that the voltages generated by new energy harvesting systems are essentially lower than kilovolt voltages that are obtained in ceramic element-based piezoelectric generators that work in direct “compression-stretching” mode. This allows usage of ordinary batteries and condensers to accumulate the harvested energy. Fig.2 shows a typical curve for 10 mF capacity condenser charging with one flexible piezoelectric element generating energy from vibration with 30Hz frequency and 0.7 g amplitude at 0.25 N load (for the obtained alternating voltage rectification a low-volt diode bridge was used). The same figure shows the dynamics of this process optimization in recent years.

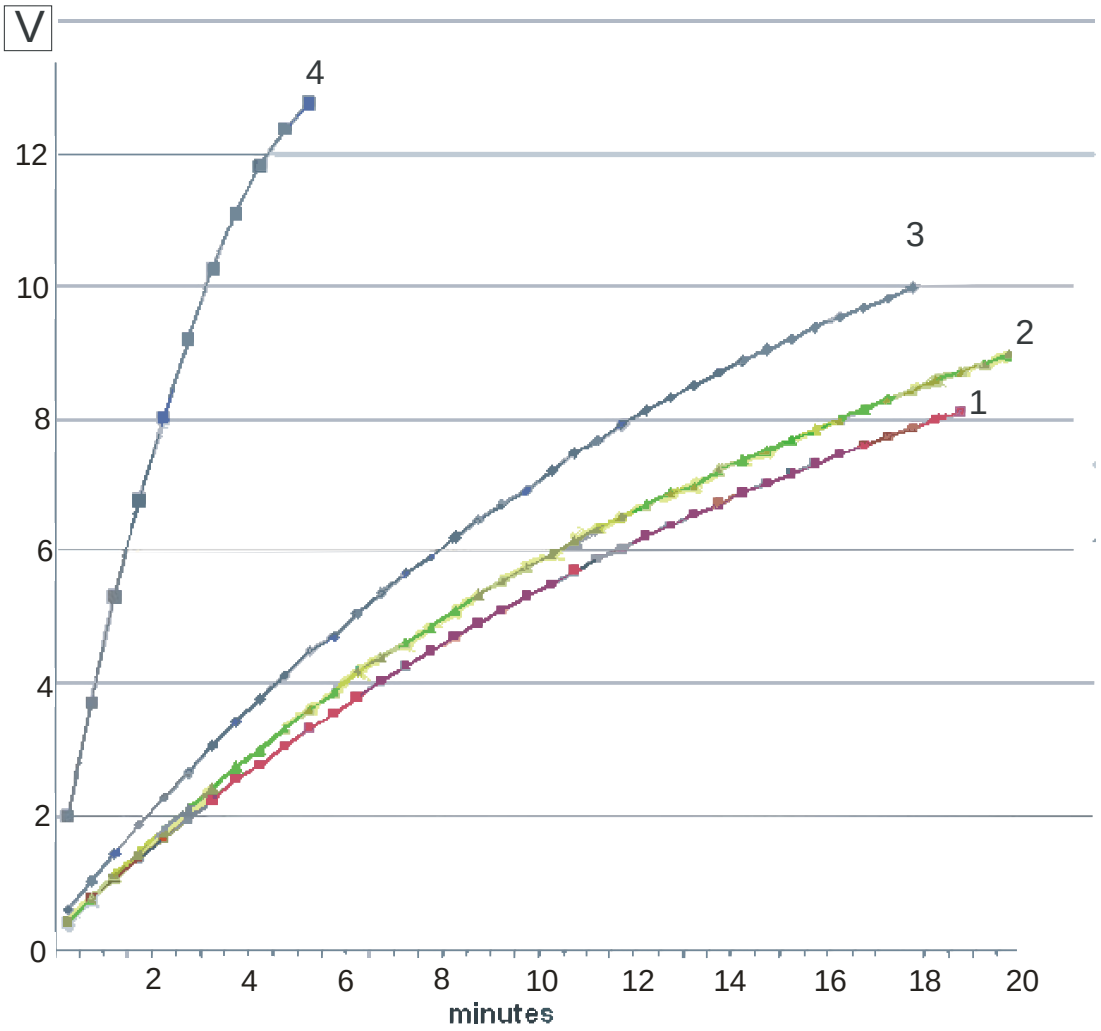

Fig.2. The rate of 10 mF capacity condenser charging with one flexible piezoelectric element generating energy from vibration (curves 1, 2, 3 and 4 correspond to the results obtained in 2010, 2011, 2012 and 2013 respectively)

It is clear from the figure that during the last three years it became possible to get a 6-time increase in the effectiveness of electric energy generation from one and the same mechanical source only for account of active element optimization.

Based on appropriate structural solutions in prospective it is possible to obtain:

- milliwatts from low-frequency vibration and similar processes;
- watts from pedestrian moving along sidewalks, underground stations, etc.;
- kilowatts from vehicle moving.

In general, it seems interesting to create Energy Harvesting Cluster which will allow working in quite a number of prospective directions (fig. 3).

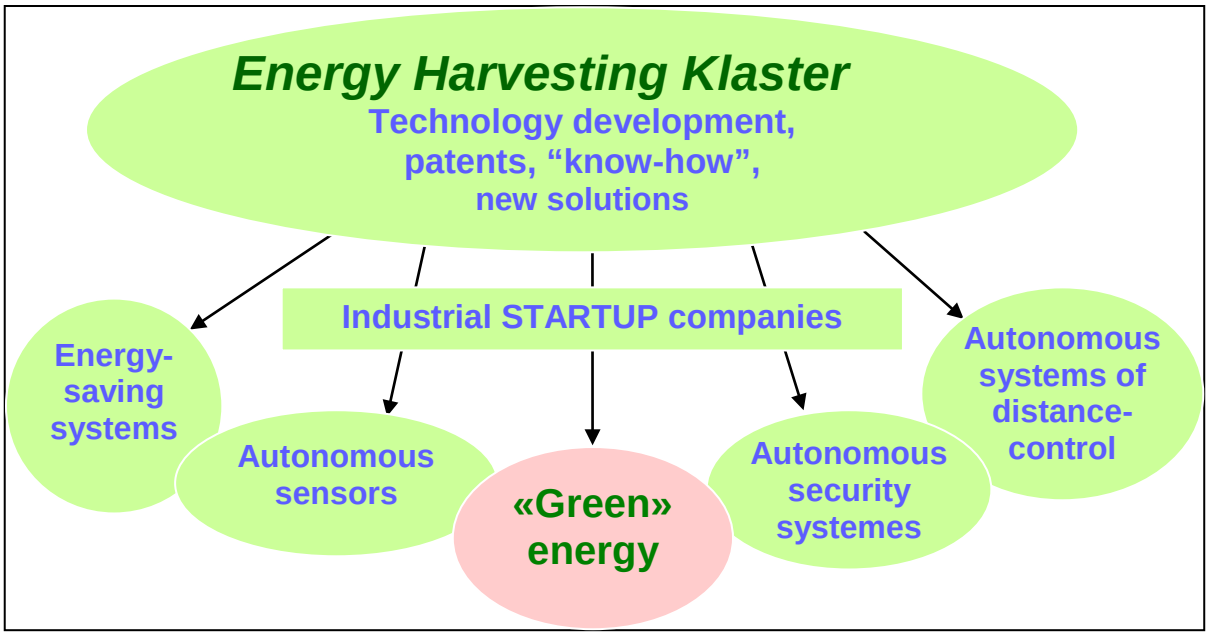

Fig. 3. Energy Harvesting Klaster

Conclusion

A new solution for systems harvesting energy from low-frequency vibration and similar processes was obtained. It is based on:

- the usage of high elastic compliance flexible piezoelectric elements;
- the application of energy harvesting mechanical systems with adaptive low-frequency resonance;
- the opportunity to create multiunit piezoelectric generators;
- the combination of electric energy generation with the favorable conditions of its accumulation.

References:

1. Guyomar, D. Towards Energy harvesting using active materials and conversion improvement by nonlinear processing. / D. Guyomar, A. Badel, E. Lefeuvre, and C. Richard // IEEE Transactions on Ultrasonics Ferroelectrics and Frequency Control. 2005. Vol. 52. I. 4. P. 584-595.

2. Lefeuvre, E. A comparison between several vibration-powered piezoelectric generators for standalone systems. / E. Lefeuvre, A. Badel, C. Richard, L. Petit and D. Guyomar // Sensors and Actuators A. 2006. V. 126, № 2, P. 405-416.

3. Hongduo, Z. A comparative analysis of piezoelectric transducers for harvesting energy from asphalt pavement. / Z. Hongduo, Jianming L. and Jian Y. // Journal of the Ceramic Sosiety of Japan. 2012. V. 120. № 8. P. 317-323.

4. Lefeuvre, E. Optimization of piezoelectric electrical generators powered by random vibrations. / E. Lefeuvre, A. Badel, C. Richard, L. Petit, D. Guyomar // Symposium on Design, Test, Integration and Packaging of MEMS/MOEMS. Stresa, Italy, 26-28 April 2006.

5. Wang, Z. L. Progress in nanogenerators for portable electronics / Z. L. Wang, G. Zhu, Y. Yang, S. Wang, C. Pan // Materials Today. 2012. V. 15. № 12. P. 532-544.

6. Patent US 2005/0127677 US 20050127677 A1, 25.01.2004. Luttrull J. K. Roadway generating electrical power by incorporating piezoelectric materials / Patent US 10/995,991.

7. Lupeiko, T. G. Old and New Problems in Piezoelectric Materials Research: Materials with high Hydrostatic Sensitivity / T. G. Lupeiko, S. S. Lopatin // Inorganic Materials. 2004. V. 40. № 1. P. 19-32.

8. Parinov, I. A. Ferroelectrics and Superconductors: Properties and Applications. Chapter 8. Computer modeling of resonance characteristics of the piezoelectric cylindrical and bimorph transducers In Ferroelectrics and Superconductors: Properties and Applications / T.G. Lupeiko,

A.V. Soloviev, B.S. Medvedev, A.S. Pahomov, M.P. Petrov, V.S. Chernov and D.S. Nasonova. N-Y.: Nova Science Publishers, 2011. P. 255-272.

9. Lisnevskaya, I. V. PZT-36/$NiCo_{0.02}Cu_{0.02}Mn_{0.1}Fe_{1.8}O_4$ Magnetoelectric Rod Composites with 1–3, 3–1, and 1–1 connectivity / I.V. Lisnevskaya, T. G. Lupeiko, I. A. Bobrova, A. V. Petrova // Inorganic materials. 2012. V. 48. № 4. P. 410-415.

10. Lupeyko T.G. Showpiece: "Green energy is a high fleksopiezogeneration", presented at the X Moscow International Salon of Innovations and Investments. 2010 (awarded a gold medal).

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Prognostic Model for Estimation of Innovative Activity Factors of Regions by Example of the Patenting Data Based on Cognitive map Modeling*

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Abstract. An approach to management of semi-structured scientific research process on the basis of dynamic cognitive map is considered. The approach takes into account interconnections of factors that influence innovative activity and is based on analysis of the following measurable parameters: research activity, innovative activity by branches of industry (applied research), number of developments (applications), demand for technology, geographical spreading, and potential efficiency of innovation.

Keywords: cognitive map; model; forecast; innovative activity; factor; patent.

Introduction

Today technological achievements and breakthroughs have become possible thanks to experience and scientific achievements. There is a trend of growing expenditures in financing of the modern scientific researches and developments. In leading countries this growth can take the lead over economic growth [9].

Forecasting allows to estimate the prospects of idea and can be considered from different points of view. First point of view is forecasting of research activities, demand in technologies, geographical spreading, financial support etc. Statistical data from patent, abstract and other databases are used for these purposes. The second point of view is forecasting of innovative projects parameters [1, 2].

Thereby there is a necessity in monitoring of other teams of researchers activity and alternative approaches to solving problems. In practice this means that working only in narrow

* From 23.06.2013 on 01.07.2013 Perm National Research Polytechnic University (PNRPU) in collaboration with the University of Applied Sciences (UAS) Anhalt (Germany) held an International summer school "Information Management". During the school were conducted master classes by leading professors of UAS Anhalt, UAS Hamburg, PNRPU, Bauman Moscow State Technical University. Perm and German universities' students enrolled in the "double degree" program, presented papers on the subject of research at the partner universities. The best 3 papers are presented in this journal.

area or within bounds of only one technology does not worth it. Researchers should keep track of new technologies appearance and improvements in competing areas.

Methods of scientific and technical work and technology forecasting, when used together, allow to discover areas that are already at the border of a new phase of development and also to make an analysis of possible alternatives and solutions. Consequently this can force appearance of new practice-oriented solutions and of innovations in the result of implementation.

Methodology of modelling of dynamic situations with the help of subjective models (cognitive maps)

For «soft» systems analysis P. Checkland [4] suggested methodology of «soft» system analysis, which represents system-oriented guidance that helps analytics to manage with analysis of complex situations. Task of decision making supporting in controlling «soft» dynamic situation is a task of developing a strategy to move situation from current condition into a goal condition on basis of subjective model of situation. This subjective model includes expert-estimated values of factors and model of functional structure, which describes known to analytic law of variation and principles of observed situation. This subjective model is represented as a directed graph, which is called cognitive map [3].

1. Building a Cognitive Map

This stage consists in picking out the set of describing situation factors and determining cause-and-effect relations among them. This expert procedure depends much on expert's knowledge and preferences.

Cognitive map (O, W) is determined by set of factor nodes of situation O and adjacency matrix of directed graph $W = \left| w_{ij} \right|$.

Scientific significance, advancement of scientific projects, and expected results can be estimated with formal methods on the stage of innovative project development. Formally economical mathematical model can be described with measurable parameters.

From the analysis considering economical mathematical model of innovation project [5] it can be concluded that factors represented in table 1 should be selected.

Table 1.

Factors and indicators of innovative process estimation on the development stage [9]

Factor	Indicator
1. Research activity	- Russian journals' reputation by SJR (according to SCOPUS data). (O_6).
2. Technology support	- Financing of Russian Humanitarian Scientific Fund from federal budgetary funds (in millions of rubbles) [20]. (O_4). - Scientific research financing from federal budgetary funds (in millions of rubbles) [12-19]. (O_5).
3. Number of developments (applications)	- Number of applications for the grant of a patent in Russia [12-19]. (O_1). - Number of applications for the grant of a patent in Russia, which were submitted by Russian applicants [12-19]. (O_2). - Number of applications for the grant of a patent in Russia, which were submitted by foreign applicants [12-19]. (O_8). - Number of applications for the grant of a patent in USA [21]. (O_7).
4. Development of technology	- Number of applications, submitted for RHSF competitions [20].

Approach based on cognitive maps is used to describe interconnections among factors. Then the parameters, which are the nodes of cognitive map and degrees of their interactions, are accounted with edges (figure 1).

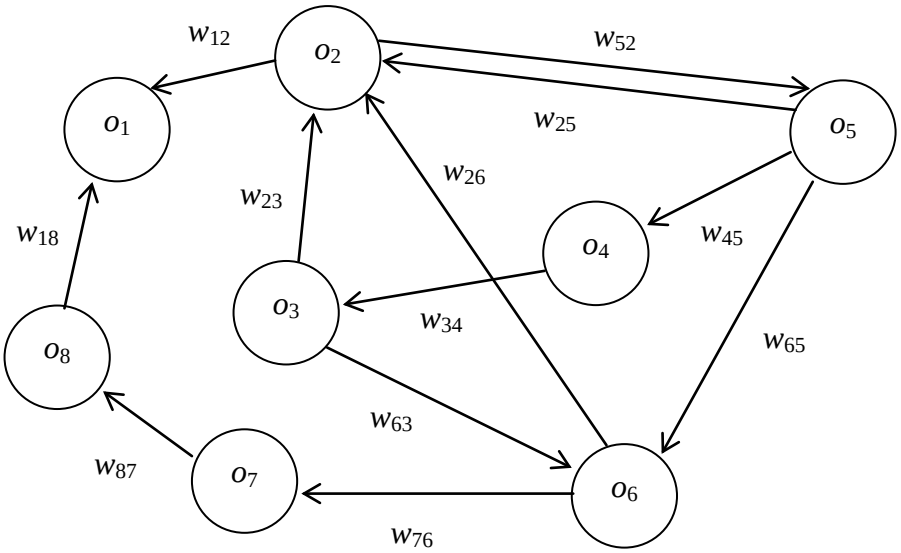


Fig. 1. Cognitive map of innovative activity

2. Cognitive Map Parameterization

It is necessary to determine weighting coefficient values (w_{ij}) in order to use the cognitive map in calculations and choose algorithm for calculation of new factors values.

Statistical data for each factor used for building innovative activity model for 2004-2011 years is presented in table 2.

Table 2.

Statistical data for 2004-2011 years

Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
	0	1	2	3	4	5	6	7
O_1	42593	45644	51775	54337	57555	53457	58759	58852
O_2	33954	35242	39776	39835	40551	38298	42460	40992
O_3	5137	5683	7783	6841	7500	8395	9313	9349
O_4	594	605	717	890	1100	1164	1000	1000
O_5	47478	76909,3	97363,2	132703	162116	219058	237657	313899
O_6	0,152	0,164	0,1705	0,18925	0,19975	0,21475	0,21375	0,2505
O_7	84270	74637	89823	79526	77502	82382	107792	108626
O_8	8639	10302	11999	14502	17004	15159	16299	17860

Factors are described by values of different dimensions (R&D financing in millions of rubbles, citing index in dimensional quantity as a decimal fraction). In order to operate with values of the same order, it is necessary to make scaling of factors' values $o_i(t)$.

Normalization of input data is a process, in which all input data are leveled, that is a reduction to interval [0, 1] is done.

Without normalization values of «R&D financing» factor will have significantly greater influence to a target factor than values of «citation index» factor. After normalization dimensions of all input and output data are reunited.

General view of normalization formula:

$$x_{норм} = \frac{(x - x_{\min})(d_2 - d_1)}{x_{\max} - x_{\min}} + d_1, \quad (1)$$

where x - value to be normalized;

$[x_{\min}, x_{\max}]$ - an interval of x values;

$[d_1, d_2]$ - an interval, to which reduction of x values is done.

Adjacency matrix of directed graph is presented in formula:

$$W = \begin{bmatrix} 0 & w_{12} & 0 & 0 & 0 & 0 & 0 & w_{18} \\ 0 & 0 & w_{23} & 0 & w_{25} & w_{26} & 0 & 0 \\ 0 & 0 & 0 & w_{34} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & w_{45} & 0 & 0 & 0 \\ 0 & w_{52} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & w_{63} & 0 & w_{65} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & w_{76} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & w_{87} \end{bmatrix} \quad (2)$$

Thereby cognitive map (O, W) is described with set of situation factors-nodes O and adjacency matrix of directed graph $W = |w_{ij}|$.

Cognitive map nodes are considered as neurons in neural networks and described with function O_i. It is done in order to minimize error accumulation in the result of expert estimations. As function O_i the following recurrent formula can be used [8]:

$$o_i(t) = \frac{1}{1 + \exp\left(-\sum_j w_{ij} \cdot o_j(t-1)\right)} \quad (3)$$

For determining weighting coefficients values w_{ij} the equations for eight nodes are transformed into the view of the following formula:

$$\sum_j w_{ij} \cdot o_j(t-1) = -\ln\left(\frac{1 - o_i(t)}{o_i(t)}\right) \quad (4)$$

As there are three unknown quantities in the equation for the node O_2, it is necessary to write down weighting coefficients equation three times for different time points (t and t-1) , (t-1 and t-2) and (t-2 and t-3), which are shifted on one time point from each other. For nodes O_1 and O_6 equations are written in the same way. In result we have eleven equations for twelve unknown variables. These combined equations are presented by the following formula:

$$\begin{cases} w_{12}\cdot o_2(t-1)+w_{18}\cdot o_8(t-1)=-\ln\left(\dfrac{1-o_1(t)}{o_1(t)}\right) \\ w_{12}\cdot o_2(t-2)+w_{18}\cdot o_8(t-2)=-\ln\left(\dfrac{1-o_1(t-1)}{o_1(t-1)}\right) \\ w_{23}\cdot o_3(t-1)+w_{25}\cdot o_5(t-1)+w_{26}\cdot o_6(t-1)=-\ln\left(\dfrac{1-o_2(t)}{o_2(t)}\right) \\ w_{23}\cdot o_3(t-2)+w_{25}\cdot o_5(t-2)+w_{26}\cdot o_6(t-2)=-\ln\left(\dfrac{1-o_2(t-1)}{o_2(t-1)}\right) \\ w_{23}\cdot o_3(t-3)+w_{25}\cdot o_5(t-3)+w_{26}\cdot o_6(t-3)=-\ln\left(\dfrac{1-o_2(t-2)}{o_2(t-2)}\right) \\ w_{34}\cdot o_4(t-3)=-\ln\left(\dfrac{1-o_3(t)}{o_3(t)}\right) \\ w_{45}\cdot o_5(t-3)=-\ln\left(\dfrac{1-o_4(t)}{o_4(t)}\right) \\ w_{52}\cdot o_2(t-1)=-\ln\left(\dfrac{1-o_5(t)}{o_5(t)}\right) \\ w_{63}\cdot o_3(t-1)+w_{65}\cdot o_5(t-1)=-\ln\left(\dfrac{1-o_6(t)}{o_6(t)}\right) \\ w_{63}\cdot o_3(t-2)+w_{65}\cdot o_5(t-2)=-\ln\left(\dfrac{1-o_6(t-1)}{o_6(t-1)}\right) \\ w_{76}\cdot o_6(t-1)=-\ln\left(\dfrac{1-o_7(t)}{o_7(t)}\right) \\ w_{87}\cdot o_7(t-1)=-\ln\left(\dfrac{1-o_8(t)}{o_8(t)}\right) \end{cases} \quad (5)$$

In order to solve the combined equations a Gauss method can be used:

$$X = A^{-1}\cdot B\ , \quad (6)$$

where A and B – matrices describing combined equations (5), X – matrix containing calculated weighting coefficients values w_{ij}.

Calculated weighting coefficients values w_{ij} .for four iterations are presented in table 3.

Table 3.

Calculated values of weighting coefficients w_{ij}

Year	2008	2009	2010	2011	2012
Iteration number	1	2	3	4	5
w_{12}	-3,1811	-0,456	3,1798	9,0855	-2,3368
w_{18}	5,4863	1,6865	-2,514	-8,438	3,7000
w_{23}	-1,6110	-0,047	-1,292	-36,86	-3,6102
w_{25}	5,3875	-0,269	-3,32	11,817	3,5417
w_{26}	0,6453	1,31	4,2226	30,206	2,1112
w_{34}	-0,1186	0,2737	0,6346	1,0224	1,2102
w_{45}	0,1884	1,8885	2,0132	0,6298	0,5806
w_{52}	-1,4977	-1,03	-0,219	0,0315	1,0397
w_{63}	5,9433	-0,397	-2,183	0,9034	26,8135
w_{65}	-15,8809	1,1362	4,2272	-0,567	-33,9059

w_{76}	-0,1052	-0,194	0,0421	1,1727	1,2185
w_{87}	0,3005	1,132	0,557	0,8714	1,0478

3. Application of cognitive modeling for technological forecasting

Suggested model on the basis of cognitive map allows to get forecast for one forward step. Statistical data for three previous iterations are sufficient for calculating factors values by analytical method with formula (3).

In order to make strategic forecast we need to know law of model coefficients variation.

New model coefficients values can be calculated when new statistical data for factors appears and dynamics can be analyzed. If we know law of variation, weighting coefficients values can be extrapolated and we can make forecast for several forward steps.

We suggest that weighting coefficients changing can be described with linear regression model represented by the following formula:

$$y = a + b \cdot x \tag{7}$$

For each weighting coefficient of cognitive map we develop linear regression models on the basis of three and four previous iterations. Regression model coefficients are calculated with least-squares method.

We can judge about model adequacy by determining the size of error [10]. We denote the experimental function by Y_E, theoretical function by Y_T and number of experimental points by n. The hypothesis can be accepted, if conditions are fulfilled: 68 % of experimental points and more should be in interval $\left(Y_T - \sigma \le Y_E \le Y_T + \sigma\right)$ and 95 % of points should be in interval $\left(Y_T - 2\sigma \le Y_E \le Y_T + 2\sigma\right)$. If not we should suggest a more complex hypothesis. Value σ can be calculated with the following formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(Y_i^T - Y_i^Э\right)^2}{n}} \tag{8}$$

For each weighting coefficient of cognitive map we developed models on the basis of three previous iterations and value for the fourth iteration was forecasted. Then we developed models on the basis of four previous iterations and value for the fifths iteration was forecasted. Real coefficient values, regression models built on the basis of three and four previous iterations and forecasted values are presented in figure 2.

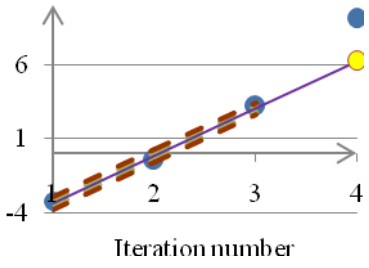
By the models presented in figure 2 we can judge that weighting coefficients models become more accurate, when new statistical data appear.

But evidently not all coefficient values can be described with linear regression models. We can make hypotheses more complex and describe coefficients with polynomials of second and third degree:

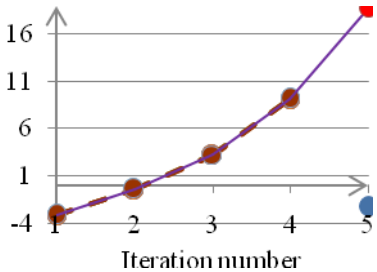
$$y = a + bx + cx^2 \tag{9}$$

$$y = a + bx + cx^2 + dx^3 \tag{10}$$

These three hypotheses are sufficient for describing statistical data. The built models were tested with the criteria mentioned above and are adequate to weighting coefficients values calculated by analytical method.



a



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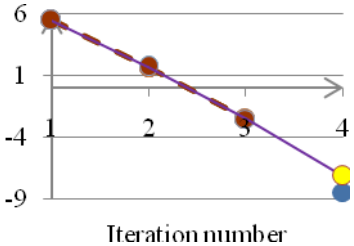
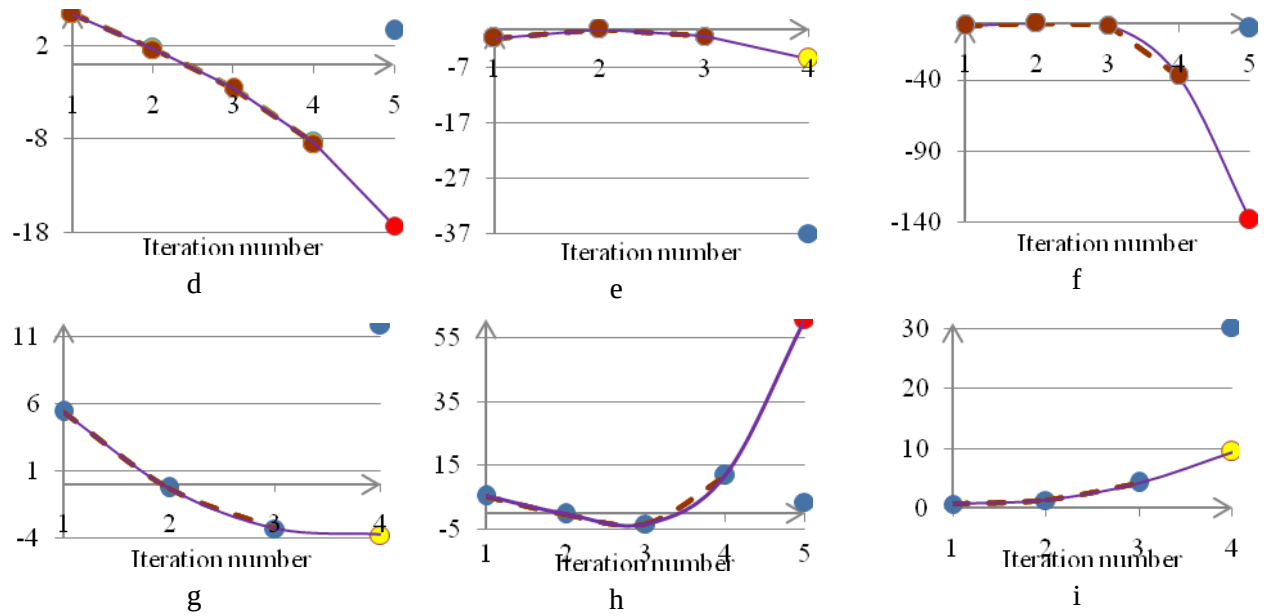


c



Weighting coefficients values w_{ij}, calculated by analytical method

Weighting coefficients values w_{ij}, predicted on regression model, which was built on the basis of three previous iteration values

Weighting coefficients values w_{ij}, predicted on regression model, which was built on the basis of four previous iteration values

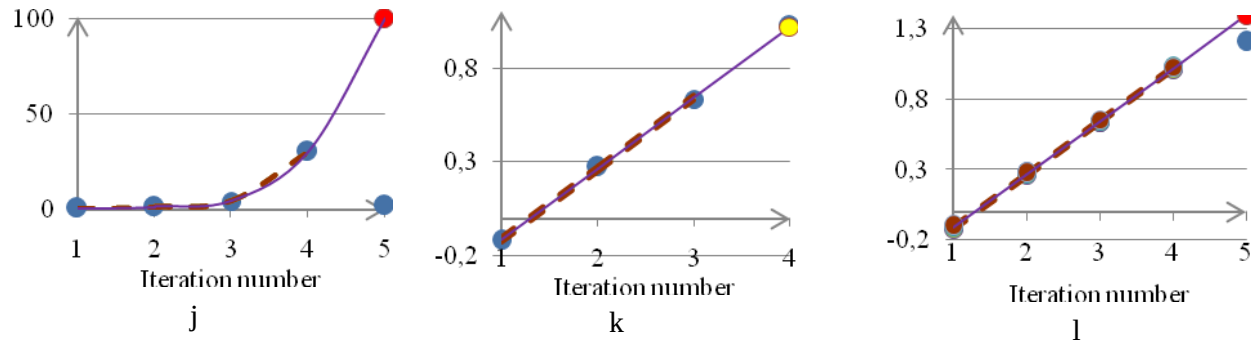
Regression model

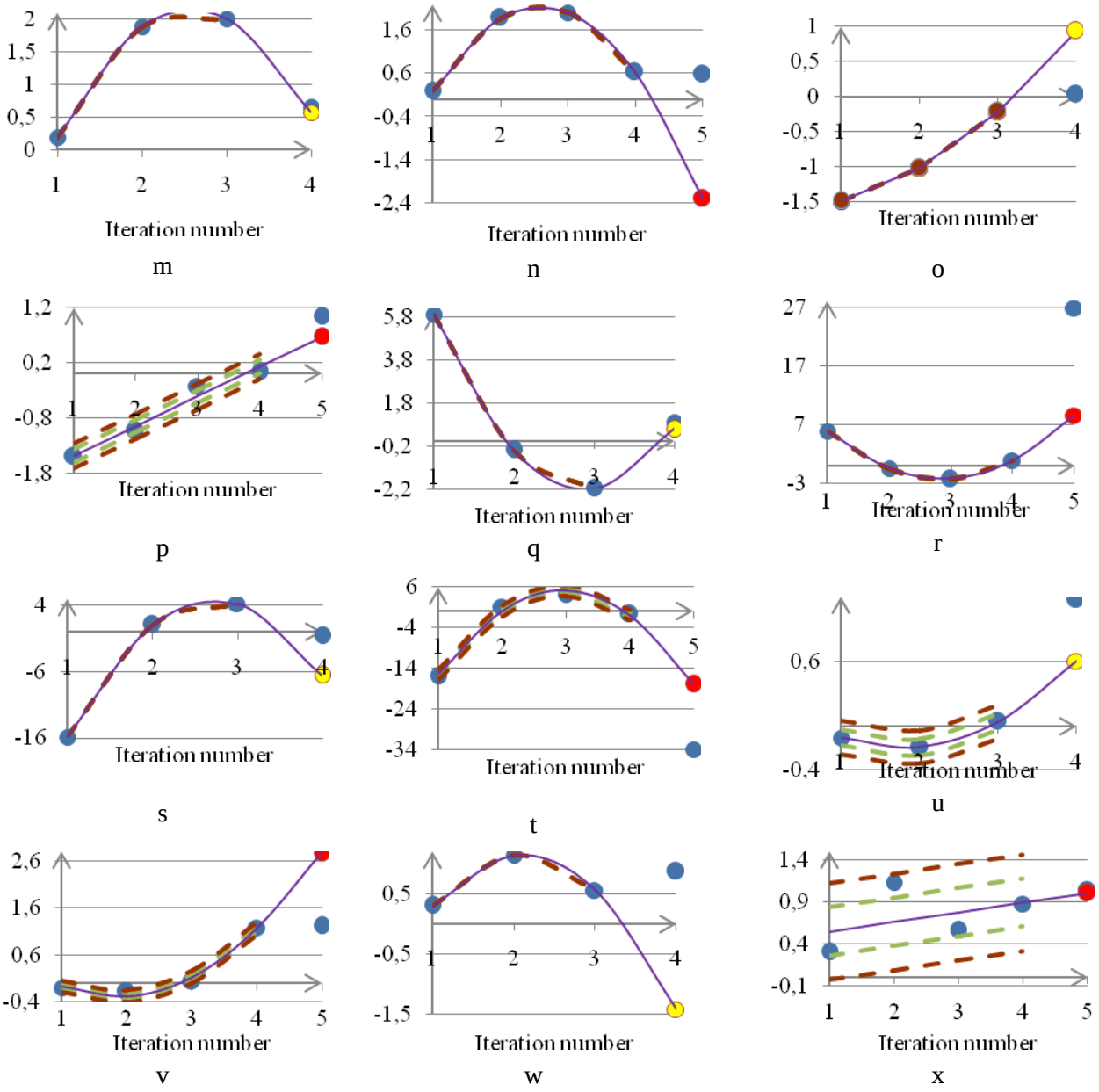
Interval $[Y_T - \sigma; Y_T + \sigma]$ for regression model

Interval $[Y_T - 2\sigma; Y_T + 2\sigma]$ for regression model

Fig. 2. Regression models of cognitive map weighting coefficients w_{ij}

Values dynamics and regression models of the following coefficients: w_{12}: a – built on the basis of three iterations, b – built on the basis of four iterations; w_{18}: c – built on the basis of three iterations, d – built on the basis of four iterations; w_{23}: e – built on the basis of three iterations, f – built on the basis of four iterations; w_{25}: g – built on the basis of three iterations, h – built on the basis of four iterations; w_{26}: i – built on the basis of three iterations, j – built on the basis of four iterations; w_{34}: k – built on the basis of three iterations, l – built on the basis of four iterations; w_{45}: m – built on the basis of three iterations, n – built on the basis of four iterations; w_{52}: o – built on the basis of three iterations, p – built on the basis of four iterations; w_{63}: q – built on the basis of three iterations, r – built on the basis of four iterations; w_{65}: s – built on the basis of three iterations, t – built on the basis of four iterations; w_{76}: u – built on the basis of three iterations, v – built on the basis of four iterations; w_{87}: w – built on the basis of three iterations x – built on the basis of four iterations.





Continuation of Figure 2

Produced calculations reveal several features related to cognitive map link coefficients calculations by regression method (some of weighting coefficients and factors differ from the other values in series, e.g. in figures 2-d, f, h, v).

First of all, little amount of statistical data significantly influences mathematical formulation even by marginal changes. There by local character, but not global tendencies can be accounted. Increase of statistical data amount or separation of noisy data can solve this problem.

Secondly, when calculating by analytical method the model accounts many influencing each other factors, and errors of estimation, related to values rounding and errors in statistics gathering, accumulate.

When developing regression models, analytical data are used and there is probability of large generalization errors, which is conditional on analytical weighting coefficients calculation method itself and connected with possibility of error accumulation.

Thereby there is a problem of separation statistical data, which bring statistical errors. Separation can be done by calculating the confidence intervals. When developing extrapolation function, according to normal distribution law 68 % of data points should be situated in interval σ, 95 % of data points in interval 2σ and 99 % of data points in interval 3σ. Economic and socio-

economic systems are described with fractal regularities, which are reflected in self-similarity of system elements. So deviation of valid data from previous values should be in interval σ, when using two previous valid data points' values.

Results of calculations of forecast values are presented in table 4.

Table 4.

Real factors values and predicted factors values, calculated by analytical method and regression model

	Real factors values O_i		Factors values O_i calculated by analytical method		Factors values O_i, calculated with regression models	
Year	2011	2012	2011	2012	2011	2012
O_1	0,6667	-	0,7157	0,7236	0,4537	0,6101
O_2	0,6436	-	0,2086	0,7961	0,4732	1
O_3	0,6667	-	0,6424	0,6667	0,5908	0,69
O_4	0,5727	-	0,5788	0,5956	0,5721	0,1766
O_5	0,6667	-	0,5053	0,6613	0,652	0,6065
O_6	0,6667	-	0,5779	0,0088	0,0497	0,0022
O_7	0,6667	-	0,6608	0,6926	0,5849	0,8641
O_8	0,6667	-	0,6403	0,6679	0,2809	0,6609

Conclusions

The suggested forecast model on the basis of dynamic cognitive map can be used in controlling the process of scientific research and development. Dynamic cognitive map can be used as information support in the process of managing of scientific research guidelines and making analysis of considered technology application field and its geographical spreading.

Parameters dynamics monitoring facilitates successful innovative activity controlling [22].

The suggested dynamic cognitive map forecast model can be used in controlling the process of scientific research and development. Dynamic cognitive map can be used as information support in controlling research guidelines and analysis of considered technology application fields and geographical spreading.

Considered approach can be used for conceptual analysis and modeling of complex and ill-defined political, economic and social situations, developing strategies of business development, and also for continuous situation state monitoring and verifying hypotheses about situation development and control mechanism [87]. It is important that your conclusion provides a summary of the achievements, further work needed and recommendations.

References:

1. Amberg M., Mylnikov L. Innovation project lifecycle prolongation method // Communications of the IBIMA. 2009. №3. pp. 11-15.

2. Armstrong J.S. Principles of Forecasting - A Handbook for Researchers and Practitioners. Kluwer Academic, 2001.

3. Axelrod R.. The Structure of Decision: Cognitive Maps of Political Elites. – Princeton: University Press, 1976.

4. Checkland P.B. System Thinking, Systems Practice. New York: Wiley, 1981.

Collopy F., Armstrong J.S. Rule-Based Forecasting: Development and Validation of an Expert Systems Approach to Combin-ing Time Series Extrapolations // Management Sci., 1992. №10(38). pp. 1394-1414.

5. Delurgio S.A. Forecasting Principles and Applications. - Boston: Irwin McGraw-Hill, 1998.

6. Easingwood, C.J., Mahajan V., Muller E.A. Nonuniform Influence Innovation Diffusion Model of New Product Acceptance // Marketing Science, 1983. №2, pp. 273-295.

7. Köller R. Konstructionsmethode für den Mashinen-, Geräte- und Apparatebau. Berlin - Heidelberg - New-York: Springer - Verlag, 1976.8. Murat Bengisu, Ramzi Nekhili. Forecasting

emerging technologies with the aid of science and technology databases // Technological Forecasting and Social Change. 2006. № 73. P. 835-844.

9. Kulinich A.A. Computer systems of decision-makin g support in ill-structured dynamic situations, based on modeling of the expert knowledge presented by cognitive maps are considered. Methods and approaches of the basic functional subsystems realization of decision-making support systems of this class are analysed // Control science. 2010. №3. pp. 2-16. (in Russian)

10. Mylnikov L.A., Trushnikov D.N. Simulation systems. Perm: PSTU, 2006. 42 p. (in Russian)

11. Robert J. Wattse, Alan L. Porter Innovation forecasting/Technological Forecasting and Social Change. Volume 56, Issue 1, 1997. pp. 25-47.

12. Sokolkin V.L. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2005. (in Russian)

13. Sokolkin V.L. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2006. (in Russian)

14. Sokolkin V.L. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2007. (in Russian)

15. Sokolkin V.L. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2008. (in Russian)

16. Sokolkin V.L. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2009. (in Russian)

17. Surinov A.E. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2010. (in Russian)

18. Surinov A.E. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2011. (in Russian)

19. Surinov A.E. Russian Statistical Yearbook. Moscow : Federal State Statistics Service, 2012. (in Russian)

20. The activities of the Russian Foundation for the Humanities in 2011 (report), 2012.

21. U.S. Patent And Trademark Office Patent Technology Monitoring Team Report, 2013.

22. Watts R.J., Porter A.L. Innovation forecasting // Technological Forecasting and Social Change. 1997. Vol. 56, Issue 1. P. 25-47.

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UDC 31

Ethnicity Changes in Backa Region: Historical Conditions and Current State

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Abstract. The paper is an attempt to observe, analyze and present ethnic characteristics of the area in a complex manner, to indicate their unity and mutual dependence, and highlight the differences from an objective point of view with the aim of finding solutions for specific problems. The aim of this paper is to analyze the ethnic composition of the area of Vojvodina part of Bačka, with special emphasis on the end of XX and beginning of XXI century. By combining historical-demographic and modern approaches in analysis of ethnicity in the region we came to the conclusion that the Serbs, Hungarians, Slovaks, Croats are the largest ethnic groups in the territory of Bačka. Although the process of ethnic homogenization is dominant, there are no ethnically pure regions, and heterogeneity in the ethnic structure of the population is the main feature of Bačka.

Keywords: Ethnicity; Ethnic homogenization; Population; Bačka; Vojvodina; Serbia.

Introduction

Since the seventies ethnicity has became the subject of numerous studies in the social sciences, but the phenomenon seems to still elude precise definition and interpretation. Ethnic boundaries in the modern world at the same time are strengthened and normalized, and ethnicity is fundamentally interwoven into the cultural and political processes. Power relations, political concepts of state sovereignty and modern political communities intersect with the concept of ethnic origin and divisions (Eriksen, 2002; Brubaker, 2004; Hall, 2004).

Multi-ethnicity is a reality for most societies, today. Intertwining of ethnic, religious, linguistic boundaries is considered to be a significant feature of the region encompassing the Vojvodina (Đerčan et al., 2011a). An issue of the interpretation and understanding of ethnic identity and power relations that are intertwined with them has not only theoretical and scientific consequences, but also very significant consequences in the social and political spheres, particularly in the Balkans. All of this is base for attempts of scientists to contribute to a better understanding of the meaning and the way in which ethnic divisions and identification function (Garment, 1993; Walter, 2004).

Formation of modern demographics, primarily ethnic characteristics of Backa, is influenced by a number of social-geographic factors. Among them of a primary importance are socio-historical factors i.e. colonization and other forms of planning, stimulated settlements and population displacements followed by wars, personal and property insecurity, border changes and the economy as well as modern urban processes. Coming to Backa, residents from emigrating, mainly neighboring countries, settled in areas where their predecessors settled - the pioneers of colonization (Bukurov, 1957). In these areas their language was spoken and cultures and traditions were fostered and thus they fit into the new environment painlessly. Such colonization created ethnic map of Bačka such as today, despite the intense mixing of the population, there is the spatial differentiation of the dominant ethnic groups in this region (Bubalo-Živković and Đerčan, 2008; Bubalo-Živković et al., 2012).

Place and research methods

Position of Bačka can be viewed from historical and geographical perspectives. The territory of Bačka is a historical-geographic area in the north of Serbia, and a small part of the territory of Bačka spreads in neighboring Hungary. As a historical region it goes back to the Middle Ages, when it was composed of two major administrative areas: Bačka and Bodrog county. After the expulsion of the Turks, the two counties have been restored, and they quickly merged into one administrative unit Bacs-Bodrog County. Until the end of World War II, this territory, based in Sombor, existed under one name - Backa. After the delimitation with Hungary (at the end of World War II), the northern part of Bačka was annexed to Hungary and the rest to the former Kingdom of Serbs, Croats and Slovenians (Jankulov, 1961; Cvetanović and Đerčan, 2009).

Bačka is one of three units in the Autonomous Province of Vojvodina and is located in the northwestern part. From the other two parts of Vojvodina it is separated by rivers, the Danube (from Srem) and Tisa (from Banat). On the north Bačka borders with Hungary, and on the west with the Republic of Croatia. The southern border toward Srem makes Danube, and the eastern border toward Banat region, in north-west makes the river Tisa (Bukurov, 1978).

Figure 1 The geographical position of Bačka in Vojvodina

On the territory of Bačka, which covers an area of 8,956 km^2, according to the census 2011 997 673 inhabitants lived or 111 inhabitants per km^2. In the study area there are 20 municipalities and cities: Subotica, Bačka Topola, Mali Iđoš from the North Bačka district, Kanjiža, Senta and Ada from the North Banat district, Sombor, Apatin, Kula and Odžaci from the West Bačka district, and Vrbas Bečej, Srbobran, Temerin, Žabalj, Titel, Novi Sad, Bač, Bačka Palanka and Bački Petrovac from the South Bačka District.

In connection with the study of changes in the ethnic composition of the population in Vojvodina there are difficulties specific to demographic research focused on the distant past. The primary factor that we have to keep in mind is the fact that ethnicity or nationality of the population for the state power, until the second half of the nineteenth century, was not of particular importance (Bubalo-Živković et al., 2011). The authorities for fiscal and defensive reasons was interested primarily in number, economic power and maybe in religion of the population, and the character of most medieval and modern censuses were consistent with these priorities (Veselinović, 1986; Gavrilović, 1991), as evidenced by numerous military, tax, urban and church records. A further problem is the fact that relatively few lists covered the whole area researched, were implemented with a unique methodology and purpose. Therefore, we can conclude that, except for the last three decades of the nineteenth century and the census in 1910 until the present time, there are only lists of people which provide indirect, partial, temporary and unsystematic information on the subject of our research, and demographic and ethnic changes can not be traced with certainty and precision (Đere, 2004).

One of the problems that arise when studying ethnic composition of the population in Bačka is a methodological census gap. Using the census data, care should be taken that there are no fully comparable definitions of permanent i.e. total population in census 2002 and earlier censuses. In Censuses 1971, 1981 and 1991, in addition to the population of the country, a permanent population also included Yugoslav citizens who worked abroad, as well as family members who stayed with them abroad.

In addition to field research for this paper, in the writing, historical method was used (archives, registers), analytic processing of studied literature and other materials, then statistical analysis of population data of censuses 1971, 2002 and 2011, cartographic, graphical method, quantitative and qualitative content analysis and comparative method. Based on the results of the census 2011, it has been made map of ethnic composition of the population in the municipalities of

Bačka, with separated municipalities with an absolute (>50%) and relative (<50%) ethnic majority. In the paper the ArcGIS 9.2 software by ESRI Company has been used.

Results and discussion

Due to the highly favorable geographical position, good natural conditions and important natural resources, the territory of Bačka was for centuries an attractive place for settlement of people (Bubalo-Živković and Đerčan, 2008).

Good natural conditions for living in this area have caused that territory of Bačka is, as well as other parts of Vojvodina, affected by constant movement of the population. The main causes are of economic, social, religious, ethnic or political character. It happened the involuntarily or voluntarily, collectively or individually, spontaneously or planned (Kicošev et al., 2006; Đerčan et al., 2010).

There are numerous historical and archaeological evidence that this territory was settled by the Illyrians, Celts, Romans, Avars, Huns, Slavs, Greeks, Hungarians, Germans and many other nationalities. In the eighteenth and nineteenth centuries Vojvodina was settled by Germans, Hungarians, Slovaks, Poles, Romanians and other nationalities (Jankulov, 1961; Gavrilović, 1972; Mitchell and Kicošev, 1997). Serbs settled in Vojvodina in huge numbers during the Turkish rule and the existence of military border. It is known the migration of Serbs in Vojvodina led by patriarch Arsenije Čarnojević, in 1690 (Đurđev, 1995). For all that Vojvodina has always been ethnically heterogeneous. It is heterogeneous today, too. Serbs are the majority, followed by Hungarians, Croats, Slovaks and others (Kicošev et al., 2006).

Ethnic makeup in the period from 1971 to 2011

The ethnic structure of the population is only subjective demographic characteristic, given that it is the result of subjective preferences of persons covered by the census. Table 1 presents the results of the censuses 1971, 2002 and 2011 in the territory of Bačka, according to ethnic structure.

Table 1 Ethnic structure of Bačka in 1971, 2002 and 2011

Ethnic Group	1971		2002		2011	
	Number	%	Number	%	Number	%
Srbs	438,540	43.83	602.371	55.78	580,805	58.22
Albanians	1,932	0.19	1,213	0.11	1,486	0.15
Bosniaks	0	0.00	287	0.03	482	0.05
Bulgarians	586	0.06	332	0.03	316	0.03
Bunjevci	0	0.00	19,650	0.02	16,324	0.02
Vlachs	15	0.00	15	0.00	28	0.00
Goranci	0	0.00	486	0.05	900	0.09
Yugoslavs	29,006	2.90	33,201	3.07	8,075	0.81
Hungarians	313,117	31.30	223,081	20.66	193,343	19.38
Macedonians	2,913	0.29	2,677	0.25	2,396	0.24
Muslims	1,909	0.19	2,355	0.22	2,236	0.22
Germans	3,992	0.40	2,064	0.19	2,079	0.21
Roma	2,125	0.21	11,062	1.02	16,860	1.69
Romanians	3,337	0.33	3.416	0.32	2,888	0.29
Russians	1,059	0.11	571	0.05	608	0.06

Ruthenians	16,856	1.68	13.483	1.25	11,915	1.19
Slovaks	37,907	3.79	29,318	2.71	25,042	2.51
Slovenians	2,342	0.23	1,144	0.11	913	0.09
Ukrainians	3,452	0.35	3,315	0.31	2,922	0.29
Croats	100,632	10.06	42,468	3.93	32,951	3.30
Montenegrins	31,424	3.14	31,960	2.96	19,831	1.99
Czechs	588	0.06	341	0.03	-	-
Other	1,807	0.18	3,670	0.34	4,016	0.40
Undeclared	667	0.07	35,454	3.28	49,052	4.92
Regional origin	3.000	0.30	6,335	0.59	16,961	1.70
Unknown	3,293	0.33	9,620	0.89	5,244	0.53
TOTAL:	**1,000,499**	**100.00**	**1,079,889**	**100.00**	**997,673**	**100.00**

Source: Censuses 1971, 2002 and 2011

In the inter-census period from 1971 to 2002 the population in Bačka increased to 79 389 inhabitants. This increase in of mechanical character , which can be explained by the large influx of refugees from war-torn areas of Croatia, followed by Bosnia and Herzegovina and at the end of the twentieth century, from the territory of Kosovo and Metohija.

According to data from the census 1996, 127 214 refugees migrated to area of Bačka, who compensated lack of population caused by negative natural increase (Kicošev et al., 2006). During the same period, population decline was recorded by almost all ethnic groups, except Serbs, Roma and Romanians. Population growth was recorded by groups "undeclared" and "undecided", "regionally undeclared" and "unknown" which is result of the unstable political situation for many years (Bubalo-Živković and Đerčan, 2008). In the inter-census period, from 2002 to 2011, population of Bačka was reduced to 82 216 inhabitants.

Based on the data from Table 1, Figure 2 is made that shows comparative data of relative share of the most dominant ethnic groups in the total population of Bačka, according to census results from 1971, 2002 and 2011.

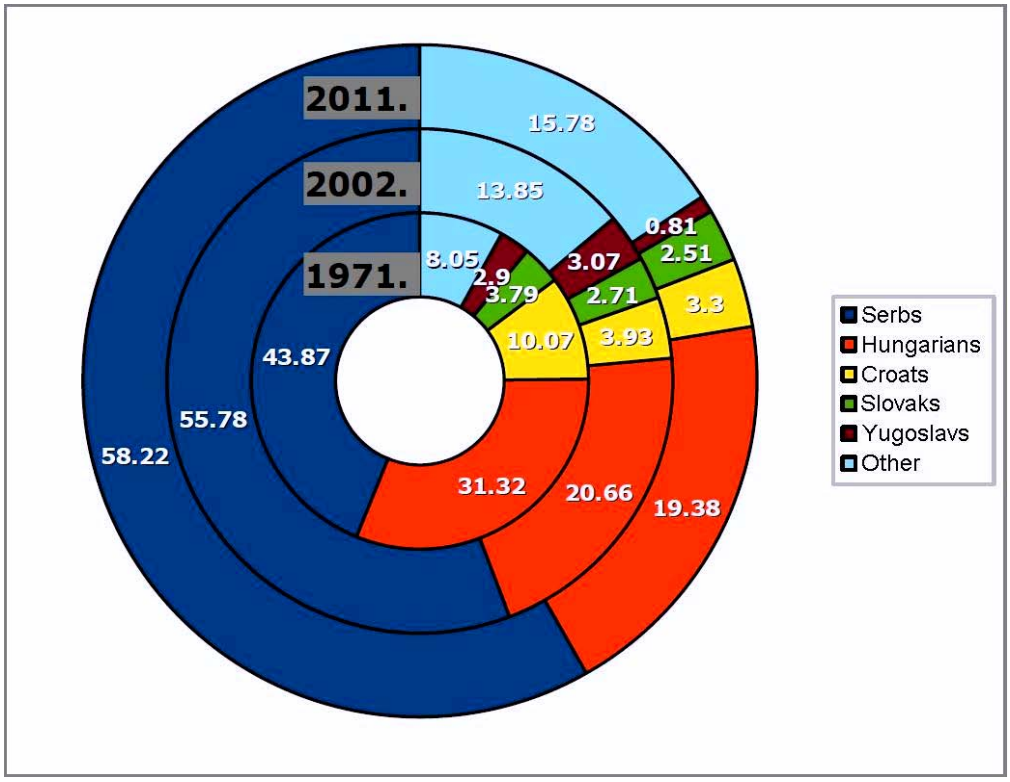

Figure 2 The most common ethnic groups in Backa according to the censuses 1971, 2002 and 2011.
Source: Censuses 1971, 2002 and 2011.

The most dominant ethnic groups in the territory of Bačka are Serbs and Hungarians. All other ethnic groups have small shares, and among them the most numerous are Croats, Slovaks, and more than 1 % of the population is consisted of Montenegrins, Roma and Ruthenians. As interesting "ethnic group" in the earlier censuses, Yugoslavs were dominant, and according to census 2011 it is "undeclared".

The number of Roma has increased by 5,798 persons, and it is observed a significant increase in the number of "undeclared" (13598) and "regionally declared" (10,626). For all other ethnic groups it is observed a decrease, most with Hungarians, Yugoslavs and Montenegrins.

Comparing the shares of different ethnic groups in the population of Bačka according to the results of the three censuses it can be seen:

- a significant increase in the proportion of Serbs (especially looking at the relationship 2002/1971);
- a significant decrease in the proportion of Hungarians and Croats in the 1971-2002 period, a slight decrease in the period 2002-2011;
- decreased proportion of Slovaks and Ruthenians;
- a significant reduction in the share of the Montenegrins;
- a disappearance of Yugoslavs and significantly increased proportion of "undeclared "
- a significant increase in the proportion of Roma.

Figure 3 presents the ethnic structure by settlements according to the census results in 2002.

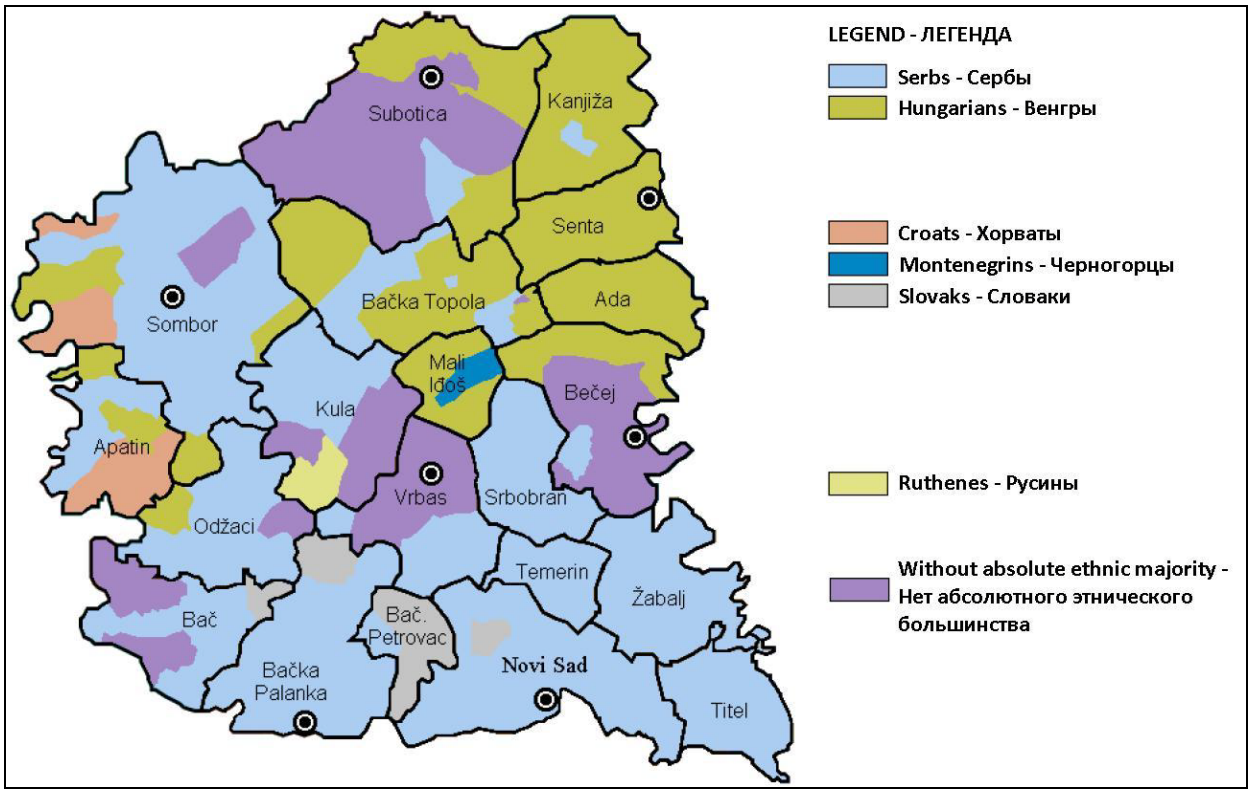

Figure 3 Ethnic structure of Backa according to the 2002 census.
Source: Census 2002.

It can be seen quite heterogeneous structure of ethnic groups in Bačka. Serbs had in 82 (in total of 166 settlements in Bačka) absolute and in seven relative ethnic majority (Kicošev et al., 2006). There is dominant concentration of settlements with an absolute ethnic majority of Hungarians near the border with Hungary and the Tisza river. Similarly, the Croats are concentrated in the border areas with Croatia. The Slovaks are in absolute majority in most of Bački Petrovac municipality, and in settlements Selenča in the municipality of Bač and Pivnice in the municipality of Bačka Palanka. Ruthenians make up a majority in Krstur, in the municipality of Kula.

Serbs

Serbs since the mid-twentieth century (1953) have become the largest ethnic group in Backa. Their share in the total population of Bačka varies between 20.4% (1910), 18.8% (1941) and 58.22% (2011). A significant increase in the number of Serbs was recorded by the census 1971. This is due to spontaneous migration mainly Serbian population from passive, undeveloped areas and as a result of natural increase, which amounted to 4-5 ‰. The increase in the number of Serbs was above the average for the total population and the share in this census reached 43.8%. Census results in 2002 registered the largest increase in the absolute number of Serbs. By this increase, Serbs for the first time made absolute ethnic majority in the population of Bačka. large increase in the number of Serbs can be found in the mechanical influx of immigrants from war- torn areas of Croatia, then Bosnia and Herzegovina, and in the late nineties from Kosovo and Metohija, too, but not in the population growth rate which shows the disturbing negative values (Kicošev et al., 2006; Đerčan et al., 2011b; Lukić et al., 2012). Based on census data from in 2011 the area of Bačka had 580 805 Serbs, which makes 58.22 %. Serbs form a majority in 10 municipalities (Sombor, Apatin, Odžaci, Kula, Vrbas, Srbobran, Temerin, Žabalj, Titel, Bačka Palanka) and the city of Novi Sad, a relative majority in the municipality of Bač.

Hungarians

Hungarians until census 1953 were the most numerous people in Bačka, and after that census they have taken second place. Their share in the total population varies between 19.38 % (2011)

and 42.4 % (1910). Absolute highest number Hungarians in Bačka recorded in census 1961 as a result of high population growth rate. The following censuses recorded decrease in all three parameters due to exacerbated biological structures and declining birth rates, and consistently negative net migration because of going abroad to work. Another reason for decreased number of Hungarians was declaration of 9,200 of them as Yugoslavs (1981) during the former Yugoslavia (Kicošev, 1990). In inter-census decade (1991-2002) there was a significant emigration of Hungarians to the home country because of the well-known political and economic circumstances in which Serbia was after in 1992 (Kicošev et al., 2006) .

According to the census 2002 the Hungarians in 50 settlements had absolute ethnic majority, and in five settlements had relative majority. It is interesting to note that the settlements Obornjača and Mali Pesak are purely ethnic Hungarian settlements (proportion of Hungarians is 100 %) and they are the only ethnically pure villages even in Vojvodina (Kicošev, 1992) .

According to census 2011 in the territory of Backa there were 193 343 Hungarians, which is 19.38%. Hungarians constitute a majority in five municipalities (Bačka Topola, Mali Iđoš, Kanjiža, Senta, Ada), a relative majority in two municipalities: Subotica and Bečej.

Croats

Croats are the third largest ethnic group in Bačka in the postwar period. Their share varies from 0.1% (1900) to 11.0 % (1961). The number of Croats continuously has grown from 1900 to the census in 1961 when they recorded their highest absolute number and proportion, followed by a decline in these indicators in the next four censuses (Kicošev et al., 2006). In addition to the unfavorable age structure and decline in population growth, going abroad to work also contributed to decline in number of Croats. Also, censuses 1981 and 1991 showed noticeably increaseed declaration of Croats, Šokci and Bunjevci as Yugoslavs (Kicošev, 1990), so Backi Monoštor in 1991 was the only town in Vojvodina, with a relative ethnic majority of Yugoslavs.

According to census 2002 the Croats in Backa had absolute ethnic majority in three towns: Senta, Bački Breg and Bački Breg i Monoštor, and in six relative majority: Djurdjin, Gornji and Donji Tavankut, Bikovo, Mala Bosna and Stari Žednik. Bunjevaci at the same time had a relative ethnic majority only in settlement of Ljutovo (Kicošev et al., 2006).

According to census data in 2011 in the territory of Bačka lived 32,951 Croats, which is 3.30%.

Slovaks

Slovaks are the fourth largest ethnic group in Bačka. Their maximum share of 4.5 % they recorded in 1900 and in 1948, and the minimum 2.51 % according to the last census in 2011. Their absolute number has constantly grown since the beginning of the twentieth century to the list in 1961, followed by steady decrease (Kicošev et al., 2006).

Censuses in 1971, 1981, 1991 and 2002 recorded continuous decrease in all three indicators, primarily due to poor biological structures and going to work abroad. Slovaks did not declared themselves as Yugoslavs to a greater extent in the census in 1981 and 1991 (Kicošev, 1990) that is they were not heavily affected by the process of spontaneous assimilation. According to the 2002 census the Slovaks in Bačka had absolute ethnic majority in six villages: Kisač, Selenča, Pivnice, Bački Petrovac, Gložan and Kulpin and relative ethnic majority in the village of Lalić (Kicošev et al., 2006).

According to census 2011 in the territory of Backa lived 25,042 Slovaks, which is 2.51 %. Slovaks form the absolute majority in the municipality of Bački Petrovac.

Ruthenians

The share of Ruthenians in the population of Bačka varies from 2.2% (1948) to 1.19 % (2011). Their absolute maximum number they recorded in the census in 1953. Census in 1971 recorded a significant decline in the number and share of Ruthenians, but it is a consequence of separation of Ukrainians as a separate category, who until then had identified themselves as Ruthenians. The following censuses recorded a slight decrease in the number and share of Ruthenians due to the unfavorable age structure. According to the 2002 census, the Ruthenians had absolute ethnic majority in Krstur and relative in Kucura. Kula and Đurđevo should be mentioned as their major centers (Bubalo-Živković and Đerčan, 2008).

Based on the data from census in 2001 in Bačka lived 11,915 Ruthenians, who made up 1.19% of the total population.

The Yugoslavs

Number of Yugoslavs varies from 29.006 (1971) to 33,201 (2002), that is, their number has increased by 4,195 persons. However, a group of Yugoslavs recorded significantly higher values in the censuses in 1981 and 1991 when it is registered over a hundred thousand people who identified themselves as belonging to this group which is not ethnic. Also, some of the Serbs began to declare themselves as Yugoslavs, which is probably the key point in the analysis of the decrease in the share of Serbs in this period (Kicošev, 1990). This fact stems from the turbulent political situation and ethnic homogeneity of the population. After the disintegration of Yugoslavia, for dome time, this group was one of the most dominant in the territory of Bačka, which can be explained by the increased declaration of population from mixed marriages.

In the last inter-census decade significantly decrease in the number of persons in this category can be seen (by 25,126) so that they now make up 0.81 % of the total population, which showed some fading of the group due to the disintegration of the Socialist Federal Republic of Yugoslavia and the Federal Republic of Yugoslavia.

Other ethnic groups

Among other ethnic groups, it should be noted increase in the number of those who are "not declared". Their number has increased from 667 (according to 1971 census), 35,454 (according 2002 census), to 49.052, so that they now make up 4.92% of the total population! Most of them live in the municipalities of Subotica (8.35%) and Sombor (7.61%). Montenegrins were in the significant category in census 1971 - there were 31 424, so that they formed 3.14% of the total population of Bačka. According to the 2002 census their number was 31.960, so that they formed 2.96%. According to the census in 2011, their number was reduced to 19,831, thus forming 1.99% of the total population. Among them also there was a noticeable effect of disintegration of the common state. Montenegrins have a prominent presence in Mali Iđoš (16.26%), Vrbas (17.47%) and Kula (10.06%). In 2002, Montenegrins had absolute ethnic majority in village Lovćenac, and in Savino Selo i Kruščić relative one.

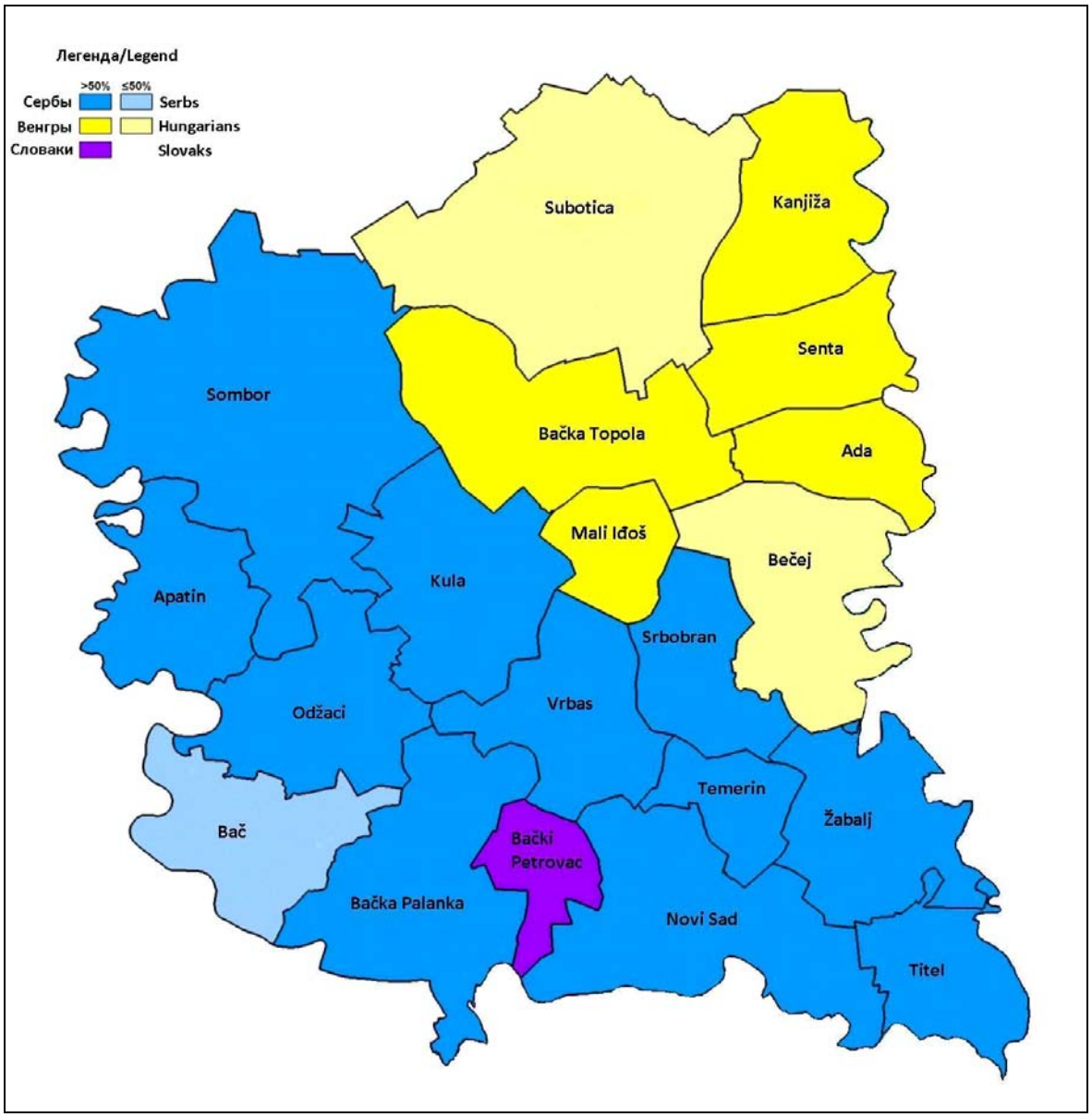

Figure 4 The ethnic structure of the municipalities of Backa according to the census 2011.
Source: Census 2011

Based on data on the ethnic composition of the municipality of Bačka, obtained by census 2011, the map 4 was made. It can be seen that Serbs constitute a majority in 10 municipalities (Sombor, Apatin, Odžaci, Kula, Vrbas, Srbobran, Temerin, Žabalj, Titel, Bačka Palanka) and the city of Novi Sad, and relative majority in the municipality of Bač. Hungarians constitute a majority in five municipalities (Bačka Topola, Mali Iđoš, Kanjiža, Senta, Ada), a relative majority in two municipalities: Subotica and Bečej. Slovaks have absolute majority in the municipality of Bački Petrovac.

Conclusion

During the period from 1971 to 2011 there were significant demographic changes in the area of Bačka. In this part of Vojvodina there are much more favorable demographic trends, because of great influence of position, as well as economic development, and migration in the past. Change in the ethnic structure of the region is largely driven by historical circumstances, refugee waves from Croatia, Bosnia and Herzegovina, Kosovo and Metohija, and negative natural increase. Refugee population has certainly influenced the change in population and ethnic structure of Bačka, but not for long. Those who remain here will certainly quickly assimilate with the indigenous population. According to the available census data Serbs were and still are the dominant ethnic group, while

the Hungarians, Croats, Slovaks and Ruthenians are declining in number, while the Yugoslavs disappear.

Figure 4 shows areas that are selected based on analysis of the ethnic composition of the population in some municipalities. This map shows that there are no absolutely pure areas in the region of Bačka, though there are parts with dominant Serbian, Hungarian or Slovak population, and that the heterogeneity is the main features in the ethnic composition of Bačka.

Although in recent years ethnic makeup of Bačka has been partly changed it continues to represent an ethnic mosaic that makes up as much as 29 ethnic groups. It should also be noted that this regionalization is not immutable category, as the population is a highly dynamic phenomena in space.

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References:

1. Brubaker, R. (2004). *Ethnicity without groups*, Cambridge: Harvard University Press.
2. Bubalo-Živković, M., Đerčan, B. (2008). Regionalizacija Bačke na osnovu etničke strukture stanovništva. *Zbornik radova Departmana za geografiju, turizam i hotelijerstvo*, No. 37, pp. 31–41.
3. Bubalo-Živković, M., Lukić, T., Đerčan, B. (2012). Demografski problemi opštine Alibunar. *Zbornik radova Departmana za geografiju, turizam i hotelijerstvo*, No. 41, pp. 70-83.
4. Bubalo-Živković, M., Lukić, T., Đerčan, B., Ivkov-Džigurski, A. (2011). Prirodne i mehaničke demografske promene i njihove posledice u pograničnim naseljima Banata. *Zbornik radova Departmana za geografiju, turizam i hotelijerstvo*, No. 40, pp. 43-58.
5. Bukurov, B. (1957). *Poreklo stanovništva Vojvodine*. Novi Sad: Matica srpska.
6. Bukurov, B. (1978). *Bačka, Banat i Srem*. Novi Sad: Matica srpska.
7. Cvetanović, M., Đerčan, B. (2009). Marital status and ethnicity in Bačka according to the 2002 census. *Geographica Timisiensis*, Vol. 18, No. 1-2, pp. 61-75.
8. Đerčan, B., Bubalo-Živković, M., Lukić, T. (2010). Demografske promene u pograničnim naseljima Srema na primeru Vašice. *Zbornik radova Geografskog fakulteta u Beogradu*, Vol. LVIII, pp. 63-80,
9. Đerčan, B., Bubalo-Živković, M., Lukić, T., Stojsavljević, R., Ćurčić, G. (2011a). Regionalizacija Bačke prema keoficijentu maskuliniteta četiri etničke manjine. *Zbornik radova Departmana za geografiju, turizam i hotelijerstvo*, No. 40, pp. 59-76
10. Đerčan, B., Cvetanović, M., Bubalo-Živković, M., Kicošev, S. (2011b). The Change in Ethnic Structure in Border Municipalities of Banat (Vojvodina, Serbia). *Geographica Timisiensis*, Vol. 20, No. 1, pp. 21-30.
11. Đere, Z. (2004). Skica promena etničkog sastava stanovništva na tlu današnje Vojvodine 1526-1910. godine. *Istraživanja*, No. 15, pp. 105-123.
12. Đurđev, B. (1995). *Posleratno naseljavanje Vojvodine*. Novi Sad: Matica srpska.
13. Eriksen T.H. (2002). *Ethnicity and nationalism*. Pluto Press, London & Sterling, Virginia.
14. Garment, D. (1993). The International Relations Dimension of Ethnic Conflict: Concepts, Indicators, and Theory. *Journal of Peace Research*, 30(2), pp. 137-50.
15. Gavrilović S. (1972). Srem, Banat i Bačka od kraja XVIII do sredine XIX veka. *Zbornik Matice srpske za istoriju*, sv. XX(6), pp. 9–26.
16. Gavrilović, S. (1991). O borbi Srba u Habsburškoj Monarhiji za političko-teritorijalnu autonomiju. *Zbornik Matice srpske za istoriju*, No. 43, pp. 7–23.
17. Hall, T. D. (2004). "Ethnic Conflict as a Global Social Problem." In: *Handbook of Social Problems*, edited by George Ritzer. London: Sage. pp. 139-155.
18. Jankulov, B. (1961). *Pregled kolonizacije Vojvodine u 18. i 19. veku*. Posebno izdanje Matice srpske, Novi Sad: Matica srpska.

19. Kicošev, S. (1990). Neki aspekti popisne kategorije Jugoslovena u SAP Vojvodini. *Zbornik radova Departmana za geografiju, turizam i hotelijerstvo,* No. 20, pp. 75-80.

20. Kicošev, S. (1992). Promene broja stanovnika Bačke tokom 20. veka. *Zbornik radova Departmana za geografiju, turizam i hotelijerstvo,* No. 22, pp. 67-74.

21. Kicošev, S., Bubalo-Živković, M., Ivkov, A. (2006). *Stanovništvo Bačke*. Novi Sad: Univerzitet u Novom Sadu, Prirodno-matematički fakultet, Departman za geografiju, turizam i hotelijerstvo.

22. Lukić, T., Stojsavljević, R., Đurđev, B., Nađ, I. and Đerčan, B. (2012). Depopulation in the Western Balkan Countries. *European Journal of Geography*, Volume 3, Issue 2, pp. 6-23.

23. Mitchell, B., Kicošev, S. (1997). A Brief Population History of the Vojvodina 1683-1718. *Geographica Pannonica*, No 1, pp. 18-21.

24. Popis stanovništva (1971). *Popis stanovništva 1971*. Beograd: Savezni zavod za statistiku.

25. Popis stanovništva (2002). *Popis stanovništva, domaćinstava i stanova u 2002, Nacionalna ili etnička pripadnost*. Beograd: Republički zavod za statistiku,.

26. Popis stanovništva (2011). *Popis stanovništva, domaćinstava i stanova 2011. u Republici Srbiji, Nacionalna pripadnost, Podaci po opštinama i gradovima*. Beograd: Republički zavod za statistiku.

27. Veselinović, R. (1986). *Srbija pod austrijskom vlašću*, Istorija srpskog naroda, IV, Beograd, pp. 106–162.

28. Walter, B.F. (2004). "Does Conflict Beget Conflict?". *Journal of Peace Research*, No. 41(3), p. 371-388.

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What Modals Are: Modal Verbs, Modal Words, and Auxiliary Modals

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Abstract. The modals are a complicated grammatical phenomenon. As of today, the status of modals is still not precisely defined in the linguistics literature, and they are described under different names: modal verbs, modal words, auxiliary modals, or defective verbs. Modals express the result of the conversion of thought processes (deep structure) about the realization of actions into surface structure. As articles determine the status of nouns as indefinite or definite things, modals determine the relation of a person to actions or the quality of an action as realizable or unrealizable. Modals cannot truly be 'modal verbs', because they lack the morphological characteristics of verbs (aspect, voice, mood, and tense), and the term 'defective verb' is flawed for the same reason. Furthermore, they cannot be 'auxiliary modals', because they don't neutralize their main meanings when they become auxiliary. Thus, I propose to refer to these elements only as modals or modal words.

Keywords: modal verbs; auxiliary verbs; defective verbs; status; realizable or unrealizable; tense category.

Introduction. There are many questions concerning the origin, name and status of 'the modals' in grammar. It is necessary to clarify several essential issues: what the modals are, what the numerous names given to the modals denote, and what their status in grammar is.

Several different names for the modals are given in textbooks: 'modal verbs', 'modal words', 'auxiliary words', 'defective verbs' and others. First, in order to be an appropriatedesignator for this notion, each of the enumerated names above should have a relevant plane of content and a plane of expression. Second, it is impossible for a single notion to be appropriately denoted by four names. These factorsindicate that this phenomenon has no certain status in linguistics.

Materials and Methods. This article was written on the basis of analyzing of huge number of sentences with modals. Different linguistic analysis were used in order to come to certain conclusions.

Main part. A human being differs from other living beings in possessing a qualitative thinking process and the ability to make inferences, judgments, and conclusions. On the basis of his/her thought process, a human being identifies positive and negative characteristics in his/her life. In solving problems, a human being takes into consideration subjective and objective written

and unwritten rules, laws, and obstacles. Only a human being has an evaluative system which works automatically, evaluating everything connected to the human being and managing his/her behavior. The objects evaluated by this system vary; they may include a person's appearance, relations, knowledge, attitude, actions and so on.

The modals are units of ` surface structure thatevaluate only the actions that a human being intends to realize. Modals determinethe necessity, possibility, or certainty of realizing these actions. Whether an action is realizable or unrealizable depends on subjective and objective circumstances or conditions. For an action to be realizable,the desire or intention of an agent is not sufficient.Certain objective conditions must also be met, such asappropriate weather conditions, sufficient finance, absence of force, etc.In the previous discussion on verbal aspect, we used the example of building a house. Everybody wants to build a house, but not everybody has the financesto purchase building materials, pay workers, acquireland, and so on. If a person has the intention and the financial wherewithal to build a house, he uses the modal word 'can': 'I can build a house'. If he has the desire, but does not presently have the funds to finance his project, he uses the modal word 'may': 'I may build a house' (in the future, if I can find the funds). He uses a modal expressing uncertainty because he doesn't know whether he'll find the money or not. If a person has nowhere to live, but he has the finances to pay for a dwelling, he uses the modal word 'must': 'I must build a house'. The above-given modals each illustrate different scenarios in which different degrees of necessity and certainty arise concerning a particular action (home construction).

Ifarticles (indefinite and definite) help to define the status of nouns in sentential propositions, the modals similarlyhelp to define the degree of realization of verbal actions. According to the manner in which they influence actions, the modals can be divided into two main groups: 'forcing' modals (FM) and 'straining' modals, which express the level of possibility/impossibility or certainty/uncertainty, respectively, of an action being realized. The modal words may be further subdividedinto those forcing (indicating the necessity of) the realization of an actions (must, shall, need, have to...); thoseallowing for the possibility of an actionbeing realized (may, might...); those advising that an action be realized (should, ought to...).

For example, the modal word 'must' signals that a person has to overcome certain obstacles preventing the realization of an action. When the phrase 'you must do this' is uttered, no alternatives are offered to the person at whom this is directed: the action has to be performed. 'You must write a report'. The report will be written; otherwise, there will be negative consequences for the subject, 'you'.

Sentences with FM usually express a high probability, possibility, or certainty of an action being realized by its agent/subject. If such modals are used with negation the action has a high possibility/certainty of *not*being realized by its agent. 'Shall' also expresses a fixed, required action. 'You shall send the goods'. The subject of this sentence (you) also fulfills the action, overcoming obstacles if there are any, because no alternatives to successful completion are offered by the modal. The sentence with the modal 'need' also forces a person to perform an action: 'I need to go to the doctor.' It is a necessity. By contrast, the modal word 'may' gives a person freedom to choose whether or not to perform the action. 'You may come.'It is your choice to go or not to go.

Let's analyze sentences in which the modal words provide opportunities to do or not to do actions.They are *may, should, ought to,* etc. 'You may come if you have time.' 'May' gives freedom to the subject (you) to come or not to come; the speaker who pronounces this sentence takes into consideration the desires of his interlocuter. The subject (you) of the sentence will resolve the action on the basis of your desires and circumstances. Now consider, 'You should go to the lessons.'In this case, the subject (you) of this sentence also has an alternative; the speaker *advises*that you go to the lessons, but the action 'to go or not to go' depends on the subject (you). The modal word 'should' offers advice without forcingthe subject, and in this respect, it differs from the modal 'may'. 'Should' expresses duty and moral obligationconcerning the realization of an action.

Modality determines a person's intention and objective circumstances. An example of a person-oriented action is: 'You must prepare the subject if you want to pass this exam'. According to the context of this sentence, everything depends on the desire of 'you'; there are no objective obstacles.

'You **may** enter a university after school'. Based on the use of the modal word 'may', the subject of the sentence 'you' has alternatives. The modals 'must' and 'may' initially define the trajectory of the actions of a person.

An example of an object-oriented action is:'Gather the hay, because it must rain, you see these heavy black clouds'. Here, one sees the objective circumstances, which don't depend on a human being.

From a linguistic point of view, the modals don't accept verbal morphology: aspect, voice, mood, number and person (although they may be integrated with tense: see below). They are usually placed in front of the main verb without changing its form (He must have read it; She should have done it).

Modals are considered to express the Tense category. For example, 'can' indicatespresent tense, while 'could' is taken to indicatepast tense. Observe, however, the contrast between 'Can I help you?' and 'Could I help you?' 'Can' and 'could' express gradations of politeness rather than temporalityin these sentences.

According to the rules of English grammar, if a sentence consists of two or more parts and the predicate of the first part is in the past tense, then the predicates of the other parts of the sentence should also be in the past tense.In that case, the pseudo-past-tense form 'could' will replace 'can'. However, 'must' is used without any alteration in the past tense.

Another question in the literature concerns whether the modals which expressedfuture tense diachronically continue to do so synchronically in Modern English. Do modals express the present tense or the future tense? Consider, for example, 'I must do that.' 'Must' is considered to be apresent tense form, but according to the context, 'must' expresses an action that will be realized in the future.

There have been trends in the literature to explain mood in terms of modality.This notion has various ideas and supporters. It is difficult to say with certainty whether modals and mood are the same or different phenomena, because both categories have an uncertain status in linguistics. Consider the traditional definition of indicative mood, which states that this mood expresses actions represented as real facts. According to this definition, the indicative mood is a completed action, which has a result. The modals foresee and define the level of realization of actions, but to call the modal 'verbs' ignores the fact that they have no verb categories.

English is an analytic language, sentential questions and negations are formed with the help of auxiliary verbs. However, it is the modals themselves that form these questions and negations, retaining their original meaning while doing so;modals do not neutralize their modal meanings when they act asauxiliaries. We have seen that modals have no direct or indirect properties of verbs.Why does the mere fact that modals are situated in front of verbs lead some people to claim that they are predicates or verbs? Adverbs are also situated in front of predicates ('he always read') or between analytical predicates ('he hasnever read'), but they are not considered to be verbs or predicates themselves. Modals lack the morphological characteristics of verbs, and they also fail to express actions.Given these facts, we cannot reasonably claim that they are either modal verbsor defective verbs.

If modals are 'auxiliary verbs', they should neutralize their main meanings when acting as auxiliaries. In order to be able to neutralize their main verbal meaning, they must first *be* verbs.

Consider a true auxiliary: to have.

- The main meaning of 'have' is 'possessing'. 'I have a car.'
- The modal meaning of 'have' together with particle TO is to force to do something. 'I have to translate this article'.
- 'Have' as an auxiliary verb neutralizes its main and modal meanings. In the sentence 'He has read,' 'has' loses its main and modal meanings when it acts as an auxiliary verb to produce the Perfect Aspect (result of action).

Unlike 'have', the modals don't meet the requirement forauxiliary verbs.For example: 'he mustread' (future + obligatory). Here, the modal simply has its modal (and main) meaning, despite appearing in an auxiliary position.

It seems, then, that we should cease to consider modals 'verbs' in any sense. Instead, I propose to simply refer to them as 'modal words'. In order to be a word, a modal element should consist of lexical and grammatical meanings, forms and functions.

Let's take the example of*must*.

Lexical meaning: obligation

Form: four letters and four sounds

Function: expresses level of realization of actions.

Grammatical meaning: indicates realization of action.

Form: degree of realization of actions.

Function: part of the predicate.

If we accept the given grammatical meaning and form, then 'must' possesses both grammatical and lexical triads. These triads provide an element with the opportunity to be a word. Since they have their own lexical and grammatical forms, meanings, and functions, the modals should be considered a separate part of speech. Let them be considered in the same context as prepositions and conjunctions, which have no morphology of their own, but are needed for morphological analyses.

What are the modals, according to traditional grammar?

I. Kant used the term 'Modalität' for the modus sense that refers to the necessity and possibility of propositions (1, 14-15). According to I.Koshevaya, "modal verbs are used to show the speaker's attitude toward the action or state. Modal verbs express a variety of moods or attitudes towards a possible state or action" [2, 263]. In J. Bybee's opinion,"modal verbs express modality, which is defined as the grammaticalized expression of the subjective attitudes and opinions of the speaker, including possibility, probability, necessity, obligation, permissibility, ability, desire, and contingency. Modality is the expression of a speaker's attitude to what his utterance denotes. The speaker's judgment may be of different kinds, that is, the speaker may express various modal meanings. Modality is one of a number of multilateral linguistic phenomenon, which have not yet found terminological or factological unification. The range of meaning of the term "modality" is so broad that modality has actually not been defined as to its meaning or its forms of representationin language" [3, 153]. She continues, "A modal verb (also modal, modal auxiliary verb, modal auxiliary) is a type of auxiliary verb that is used to indicate modality –likelihood, ability, permission, and obligation." [4, 33].

There are several types of modal meanings according to modern modal logic:

- alethic modality (Greek: *aletheia,*'truth') defines the possibilities or impossibilities of actions on the basis of inferences;
- epistemic modality (Greek *episteme,* 'knowledge') defines the possibilities or impossibilities of actions on the basis of knowledge;
- deontic modality (Greek: *deon*, 'duty') defines the possibilities or impossibilities of actions on the basis of principles, laws, rules and 'unwritten laws and rules' [5, 373].

Modality expresses the wide range of human intentions as demonstrated in the form of realization or non-realization of actions: (1) obligation (strong), (2) obligation (weak), (3) permission, (4) volition, (5) prediction, (6) ability, (7) possibility, (8) inference (strong), (9) inference (weak), (10) hypothesis [6, 27].

G. Leech gives 11 types of modal meanings: (1) possibility (theoretical, factual), (2) ability, (3) permission, (4) rules and regulations, (5) obligation/requirement, (6) exclamatory wish, (7) logical necessity, (8) prediction/ predictability, (9) willingness (weak volition), (10) intention (intermediate volition), (11) insistence (strong volition) [7, 73].

D.Mindt suggests the following modal meanings: (1) high probability/ possibility, (2) certainty/prediction, (3) ability, (4) hypothetical event/result, (5) habit, (6) advisability/ desirability, (7) obligation, (8) inference/deduction, (9) volition/intention, (10) intention, (11) politeness/ downtoning, (12) consent, (13) state in the past, (14) permission, (15) courage, (16) regulation/prescription, (17) disrespect/insolence [8, 13].

These modals show that there are many different modal manifestations. Human beingscannot live without modals; they give sense and reason to life and help to define or foresee a person's ability to do or not to do something.

"In Middle English *shall + will + Infinitive* are used as pure future , *shall* at first much more frequently than *will* . *Will* afterward came into more generaluse, till at last in many dialects—such as the Scotch—it has completely vanquished *shall" [9.93].* The lexical meanings of 'shall'

(obligation) and 'will' (will) are modal. For example: 'You shall bring my book' (warning). The modals 'shall' and 'will' have several meanings, ranging from permission to threat.

*Shall h*as the meaning of

- permission: *Shall* I bring these newspapers?
- prediction*:* He *shall* come. It may take more than a week.
- strong determination: He wants to meet her; he *shall* do it.
- obligation: You *shall* report about it to the boss.
- necessity: *Shall* I recite this poem?
- and so on...

'Shall' belongs to the FM type, which forces a person to realize an action without giving an alternative solution. 'Shall' strictly organizes actions, which is why it is used in commercial and military correspondences, where noobjections are permitted, and everything will be done (or not be done) according to instruction. "Will" also expresses modality:

- instant decisions: I can't see any ideas from you, that is why I *will* solve this problem by myself.
- offer: I *will* come if you like
- and others.

'Shall' and 'will' express modality and futurity simultaneously. As auxiliary verbs, they organize futurity ('You *will* come').Since they carry the meaning of both futurity and modality , the question arises whether 'shall' and 'will' are pure indicators of Tense, pure indicators of modality, or both at once. For example, 'shall', when used as a modal word, has the meaning of intention. 'I shall go to the university'. What kind of meaning is expressed by 'shall' in this sentence? 'Shall'indicates temporality, since the action 'go' will be realized in the future; however, it also indicates modality,since the intention of the subject will be realized in future. 'Shall' expresses two meanings, futurity and modality, in one form. Similarly, in the sentence 'You *will* bring my book tomorrow', futurity and modality as expressed simultaneously.

In order to express the pure future tense, the subject of a sentence must be an objective thing, without human intention. For example: It will rain. The process 'raining' doesn't depend on a person's intention; it depends on objective chemical and physical properties of air and many other things.

According to the history of the English language, there were, diachronically, no special indicators for future tense. Futurity was indicated with the help of adverbs and modals. Examples of this phenomenon still exist today. For example:

1) He arrives tomorrow.
2) He is arriving tomorrow.
3) He is going to arrive tomorrow.
4) He is about to arrive.
5) He must arrive tomorrow.

These examples of future tense all occur without 'shall' and'will'. Each of them has its own context of use. They continue to be used in Modern English despite the fact that shall' and 'will' are considered to be the indicators of future tense.

'Shall' and 'will' do not lose their modality when combined with aspects and voices: 'When you come at night, I'll be sleeping' - modality (supposition) plus futurity. 'Shall' and 'will' differ from other modals (must, can...). They are part of a single conjugation ('I shall', 'you will')indicating futurity in some English variant, but in the American variant, 'will' is used with all persons for futurity and 'shall' is used as an indicator of modality. If we compare 'shall' and 'will' with traditionalmodal verbs must, can, may, etc, the similarities are:

- express only future tense
- modality

Differences between 'shall" and 'will' and the rest of the modal verbs are:

- 'shall' and 'will' can combine with certain persons and aspects as indicators of futurity: I, we shall; you, he, she, they will (You will have sold it by this year - futuruty; but: He passed exams , he must have prepared – logical conclusion in the Past).
- 'shall' and 'will' combine with certain persons as indicators of modality in English variant : I, we will; you, he, she, they shall. (I shall –futuruty; I will – modality)

• the rest of the modals combine with all persons equally as indicators of futurity and modality.

Results. The modals express the certainty, possibility, or necessity of a planned action being realized, Modals have no morphological verb characteristics (aspect, voice, tense, mood, number, and person), so we can conclude that they are neither modal verbs nor defective verbs. They are also not auxiliaries, because they don't neutralize their main meanings in order to appear in an auxiliary context. Modals reflectboth human intentions and objective circumstances as factors determining whether an action will be realized. They are words whose lexical meanings express degrees of realization of actions.

References:

1. Immanuel Kant. 1781. Critik der reinen Vernunft. Riga: Johann Friedrich Hartknoch. 14-15).

2. Кошевая И.Г. Теоретическая грамматика английского языка: Учеб. пособие для студентов пед. ин-тов по спец. №2103. "Ин.яз."М.: Просвещение, 1982. 336 с.

3. Bybee, Joan 'The Semantic Development of Past Tense Modals in English'. Bybee, Joan & Suzanne Fleischman (eds.), 1995. 517 p.

4. Palmer, Frank R. Modality and the English Modals. London/New York: Longman, 1979, 2nd ed. 1990. 653 p.

5. Прохоров А.М. Философский энциклопедический словарь. М.: Изд. Советская энциклопедия, 1989. С. 494–595.

6. Coates J. The Semantics of the modal auxiliaries. London & Canberra: Croom Helm, 1983.-27p.

7. Leech, G.N. Meaning and the English Verb. London: Longman, 1971; 2nd ed. 1987. 563 p.

8. Mindt, Dieter. An empirical grammar of the English verb: modal verbs. Berlin: Cornelson, 1998. 145 p.

9. H.Sweet. 1898. New English grammar // Part II-Syntax. Oxford. Clarendon Press.

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Linguistic & Rhetorical Paradigm as Innovative Theoretical Methodological Platform of Studying Discursive Processes of East Slavic and Western Cultures

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Abstract. The paper suggests studying conceptual models and mechanisms of linguistic consciousness of East Slavic and Western cultures with the application of the theoretical methodological approach of Linguistic & Rhetorical (L&R) Paradigm as an integrative philological trend of an innovative type. The L&R Paradigm rests on the intersection of three categorical dimensions: ideological aspects of a speech event (ethos, logos, pathos); stages of universal cycle of idea-into-speech transformation (invention, disposition, elocution) as a technology of discursive processes; levels of the structure of a linguistic personality as a discourse producer and ideology bearer (associative verbal network, thesaurus, pragmatic field). Hence, the article proposes three groups of L&R parameters of studying speech and thinking phenomena: ethos-motivational-dispositional; logos-thesaurus-inventional; pathos-verbal-elocutionary.

Keywords: linguistic & rhetorical (L&R) paradigm; levels of linguistic personality: verbal semantic; linguistic cognitive; motivational; ethos, logos, pathos; invention, disposition, elocution; conceptual model; linguistic consciousness mechanisms; ethnic cultural specificity.

Introduction. Modern development of philology witnesses an integration of particular fields of linguistics, communicative studies and applied linguistics with the systematic linguistics, describing language levels in synchronic and diachronic planes, with general rhetoric and derivative disciplines studying the functional linguistic aspect and encompassing stylistics, speech culture, pragmatics as well as a wide range of literary disciplines, applied linguistics and methods of teaching literature.

The scholars' attention to the study of conceptual models and mechanisms of linguistic consciousness in East Slavic and Western cultures from the L&R paradigm perspective makes the following directions of investigation especially promising:

- modeling cognitive constructs with respect to the specificity of L&R implementation of strategies and tactics in discourse (institutional / individual) and in text by senders and receivers as representatives of the cultures under study;

- determining and differentiating conceptual models of sender / receiver's linguistic consciousness treated as rhetorical constructs of different types, as synergetic products of linguistic personalities of various ethnic and cultural types;

- revealing the peculiarities of functioning of linguistic personality – the subject of discursive processes – with respect to the universal "idea-into-speech transformation" cycle which verbalizes ethos, logos and pathos of a speech event embodied in universal, ethnocultural and individual values, ideological stereotypes, and attitudes;

- development of L&R foundations of investigating and forming the mechanisms verbalizing the consciousness of the representatives of heterogeneous ethnic societies with respect to the specific type of a linguistic personality: collective, socially stratified, individual etc.

Sources and methods. The L&R paradigm research tools applied to the complex comparative study of political, media and psychological types of discourse practices include the following major *methods and procedures of analysis*:

I. L&R paradigm as an innovative research approach and the initial point of analysis.

II. General research methods of systematic analysis, concept categorization, modeling, quantitative analysis etc.

III. Philological methods and procedures:

- methods of contextual, descriptive, structural semantic, cognitive analysis as well as stylistic, distributional, hermeneutic interpretational etc, applied to the specific textual material;

- L&R method of three groups of universal L&R parameters aimed at studying the speaking and thinking phenomena and their textual representation;

- L&R method for revealing the universal, i.e. the invariant core, and the changeable components in the structure of the studied discursive practices and of linguistic / literary personality of particular groups of individuals which include politicians, scientists, writers etc;

- the linguistic procedures of observation, description, comparison, speech and language distribution, linguistic and extralinguistic correlation;

- original L&R techniques of "primary L&R reconstruction", "secondary L&R reconstruction", "generalized L&R reconstruction". *The primary reconstruction* consists in an empirical step-by-step analysis of the studied texts with the application of three groups of parameters. The *secondary* L&R reconstruction is aimed at the analysis of the texts of the scholars who have already investigated the empirical material under study. Their papers serve as an empirical material of the second level and their findings are classified from a more general vantage point offered by three groups of L&R parameters which being universal can be found in any text. The *generalized* reconstruction capitalizes on the results of the two procedures discussed above.

Discussion. In the vein of the humanistic tendencies in science and education the integrating core for all the fields of philological study turns out to be a linguistic personality, which performs a universal "idea-into-speech transformation" cycle and implements the integral L&R competence. The stages of the rhetorical cycle go back to the classical rhetorical canons which from the perspectives of communication theory and psycholinguistics can be perceived as an integral program of transforming an idea into speech: invention (the choice of an idea), requiring the analysis of a topic with its subsequent categorization on the basis of a selection grid of data; disposition, or arrangement, as a linear exposition of a referent and its syntagmatic patterning; elocution, or the use of linguistic units serving for referent verbalization or text-formation [1, 2].

We have been developing the L&R approach to the study of language, discourse, text, belletristic works since the early 90-ies combining the ideas and conceptual apparatus of the anthropocentric linguistics and new rhetoric which developed in the course of the so-called "rhetorical Renaissance" [3]. As V. N. Toporov puts it, "being part of semiotic studies, rhetoric has a range of common problems with linguistics and opens up opportunities for further – deliberate – contact between rhetoric and linguistics with the latter making an advantageous use of the former" [4].

In this framework, *we define the L&R paradigm as a hierarchy of concepts, theoretical attitudes, and terms produced by the interdisciplinary synthesis of linguistics and rhetoric* [5].

The L&R method proper results from the intersection of three categorical dimensions:

1) methodological categories of ethos, logos and pathos which formed the basis of ancient rhetoric and now return to philology: ethos (Gr. character) – ethic, moral and philosophical

foundation of speech; logos (Gr. arguments) – verbal and intellectual foundation of speech; pathos – (Gr. suffering) [6] – the emotional foundation of speech;

2) levels of a linguistic personality as a bearer of ideology, creator and product of language: verbal semantic level, or associative verbal network; cognitive linguistic level, or thesaurus; motivational level, or pragmatic field [7];

3) stages of the idea-into-speech transformtion going back to the canons of classical rhetoric and underlying the discursive embodiment of ideology in speech: *invention* (selecting and finding an idea); *disposition* (the arrangement of invented arguments); *elocution* (verbal ornamention).

An ethnic group's agregate linguistic personality with its collective pragmatic field, thesaurus, and associative verbal networks embodies the spiritual constants of ethos, logos, pathos creating the inventive-dispositional-elocutionary space of the global discourse. Consequently, one can name three groups of universal L&R parameters implemented in various types of discourse: ethos-motivation-disposition; logos-thesaurus-invention, and pathos-verbalization-elocution.

The theoretical foundations of L&R paradigm rest on combining the concepts of ancient and new rhetoric with those of linguistics, psycholinguistics, pragmatics, communication theory, textual linguistics, applied linguistics as well as the L&R terms proper which have emerged in the course of our research: L&R competence of a linguistic personality and mechanisms of its implementation; the aggregate linguistic personality of an ethnic group; L&R worldview; L&R procedure of a secondary reconstruction, L&R education (upbringing, development) [8] etc.

The L&R paradigm boasts a profound integrational and heuristic potential, its methodological status rests on the anthropocentric linguistics, new rhetoric, the general integrational tendencies of philological disciplines. The paradigm is subordinated to the tasks of reforming the system of school linguistic education, of higher school training professional linguistic personalities for the spheres of philology and pedagogics, law and management etc.

Perceiving language as a way of linguistic personality's social cultural existence, as an environment of "linguistic existence", i.e. the never ending life "with language" and "within language" [9], we leave the level of "pure" linguistics and move up to the L&R treatment of language as a means of speech activity resting on a system of communicative events, contributing to the implementation of a linguistic personality's L&R competence. The L&R approach shifts the focus of researcher's attention from isolated linguistic structures to their rhetorical role in speech. The verbal parameters of thinking constitute an inventional-dispositional-elocutionary continuum of speaking and thinking space.

The L&R mentality as a national historical dominant of linguistic personality's self-realization influences all communication levels:

1) speech act level;

2) level of a speech action as a chain of communicative acts united by a common aim;

3) level of communicative behavior, encompassing speech actions perceived from the perspective of their schematic characteristics pertinent to a particular individual;

4) level of speech policy as a state-initiated strategy of a desirable communicative behavior in the framework of an ethnic group's aggregate linguistic personality.

As soon as we turn to the theoretical methodological dimension of the L&R approach, the term *speech* is replaced by the term *linguistic & rhetorical*. However, within the "language – L&R competence of a linguistic personality" framework the correspondence of the three main facets of the investigation seems quite possible: "language and system", "language and text", "language and ability" (cf. [11]).

Within the integral L&R competence two constituents with the corresponding subcompetences can be singled out: 1) the linguistic one dealing with language; 2) the rhetorical one with its textual and communicative subcompetences. Being an instrument of implementing discursive text-forming process, L&R competence manifests itself in the associative verbal network, thesaurus and pragmatic field of a linguistic personality, serves as a qualitative feature of activity and communication needs, expresses a degree of adequacy and completeness of an individual worldview, reflects the vocabulary richness in the mother tongue and in a second language.

Singling out the mechanisms of implementing L&R competence which contribute to a linguistic personality's effective thinking speaking activity, we draw on correspondences between the parts of classical rhetoric (invention, disposition, elocution, memory, delivery) and psycholinguistic stages of activity which include orientation, planning, implementation, control.

The ensuing mechanisms – predispostional orientational, inventional paradigmatic, dispositional syntagmatic – can be treated as linguistic personality's psycholinguistic formations. Being complexes of interacting speaking and thinking skills, they provide for the implementation of communicative, textual and linguistic subcompetences of a linguistic personality in different communicative forms (monological, dialogical), registers (receptive analytical, reproductive constructive, productive creative), forms (oral, written) of sociocultural speech communication, in different styles and types of speech, in colloquial and literary genres.

Integrated into the general communicative model, the system of emerging interrelations is projected onto the linguistic code and contributes to the transparency of the "language – speech – speech activity" triad as a social cultural phenomenon produced by an ethnic group's aggregate linguistic personality.

According to F. de Saussure, speech activity is considered as a unity of related but non-equal language and speech phenomena treated as part and whole. The Russian psycholinguists – A. A. Leontjev, I. A. Zimnyaya and others – define speech activity as a process of reception and production of a message with the help of linguistic means in a communicative situation. It is also suggested that the ontology of language and speech as two different realities should be treated as "a transformation and transmission of two substances instead of perceiving them in terms of part and whole or of superimposition" [12].

Procedural units of social linguistics – sociolinguistic variables – are singled out with respect to their relation to a particular level of linguistic structure and to the variation of social structure and social situations [13]. In the L&R framework those units can be treated as social L&R variables related to the following components: levels in the structure of a linguistic personality (collective, aggregate, individual, collegial, ethnically stratified); the peculiarities of implementing the stages of universal idea-into-speech transformation cycle aimed at the ideal correlation of the speaking and thinking process results with the speech topic, communicative situation and psychological peculiarities of the addressee; the anthropocosmic ethos-logos-pathos continuum of ideological L&R structures forming the mentality of an ethnic group's aggregate linguistic personality at all the levels.

The linguistic & rhetorical constants of speech communication which were discussed above are represented in Figure 1.

The application of L&R paradigm tools to the study of East Slavic and Western culture is exemplified here by the analysis of A. Pushkin's classical verse "Prophet":

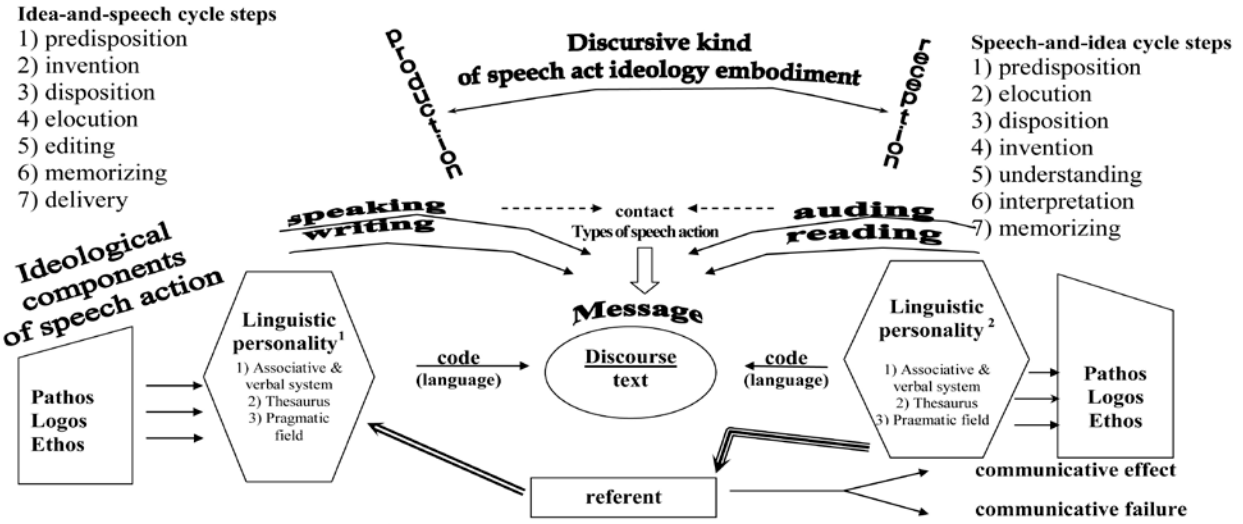
'*With fainting soul athirst for Grace*' is a predisposition: a feeling of spiritual thirst as a receptive intention emerges at the motivational level of a linguistic personality, it is embodied in a desire to partake Ethos, Logos, Pathos from the Cup of Higher Intelligence in order to put sense into earthly existence;

'*I wandered in a desert place*' is an exposition of the circumstances of communication, a description of its physical and psychological conditions from the metaphorical perspective; direct and figurative sense of the represented frame; the linguistic personality's world perception; data of its thesaurus; negative connotations of the lexical unit *wandered*;

'*And at the crossing of the ways / I saw a sixfold Seraph blaze*' represents the emergence of the first participant in the supernatural communication – a potential addressee – sixfold Seraph, a messenger of the Holy Spirit; his description; metaphoric communicative situation of *the crossing of the ways*; further specification of the communication location. The metaphoric use of the lexical units *the crossing of the ways* and *saw* reveals the meeting of the conversation participants and their non-verbal interaction; the specificity of modus and dictum synthesis is reflected in the religious mystical vocabulary; appeal to the rhetorical hermeneutic circle.

Figure 1

LINGUISTIC & RHETHORICAL CONSTANTS OF SPEECH COMMUNICATION



Force lines of psychoenergetic interaction:
1.Linguistic personality[1] associative and verbal system → Linguistic personality[2] associative and verbal system
2. Linguistic personality[1] thesaurus→ Linguistic personality[2] thesaurus
3. Linguistic personality[1] pragmatikon→ Linguistic personality[2] pragmatikon
Processes of denotation: Linguistic personality[1] logos → Linguistic personality[2] logos
Modus and connotative instillations: (Linguistic personality[1] ethos → Linguistic personality[1] pathos)→ Linguistic personality[2] ethos (reception) → Linguistic personality[2] pathos (reproduction, production)

'*He touched mine eyes with fingers light / As sleep that cometh in the night*' is a further specification of the features characterizing the addressee; the strengthening of the non-real; a description of the non-verbal communication act beginning.

'*And like a frightened eagle's eyes / They opened wide with prophecies*' is a description of the communicative effect of the non-verbal communication: the presentation of a new visual / perception ability, directed by the excited spirit, by a feeling of an elevated anxiety; the lexical unit *prophecies* indicates a potential referent – the whole universe without enumeration of specific referents.

'*He touched mine ears, and they were drowned / With tumult and a roaring sound: / I heard convulsion in the sky, / And flight of angel hosts on high, And beasts that move beneath the sea, / And the sap creeping in the tree*' is a portrayal of the communicative effect of the non-verbal communication: enumeration of specific referents perceived by the more sensitive organs of the transforming linguistic personality.

'*And bending to my mouth he wrung / From out of it my sinful tongue, / And all its lies and idle rust, And 'twixt my lips a-perishing/ A subtle serpent's forkèd sting / With right hand wet with blood he thrust*' is a description of the preparatory stage of the non-verbal communication regulating the future thinking and speaking activity of the prophetic linguistic personality; negative connotations characterizing daily speech activity of an ordinary linguistic personality differing from the Poet; the supernatural transformation of the associative verbal network of an ordinary individual.

'*Then in the desert I lay dead*' describes the communicative situation from the perspective of the addressee's state: the maximal intentional readiness, a state of a blank sheet of paper.

'*And God called unto me and said:*' represents the supreme addressee, Linguistic Personality No 1 (recall from the Bible "*At the beginning was the Word, and the Word was God*") activates all the structures of the addressee's linguistic personality ready for this supernatural communication.

'*Arise, and let My voice be heard, / Charged with My will go forth and span*' is the supermonologue, a persuasive speech produced at the global scale; illocutionary superforce; performatives, imperative sentences, order, direct influence, suggestion; completion of restructuring the motivational level of the addressee's linguistic personality, explicit formation of the leading activity communication need as the dominant of the Poet's pragmatic field.

'*The land and sea, and let My word*' is the creation of an image of the Poet's potential audience encompassing the Universe.

'Lay waste with fire the heart of man' indicates the restructuring of the motivational level of the potential speech receivers of "the second level" resulting from the fan-like communication which demonstrates the geometrical progression of verbal communication, the dialectal interaction of intentionality and of the intention of the inseparable L&R chain.

The analysis of A. Pushkin's verse "Prophet" is summarized in the following table:

Table 1. Implicite L&R and applied linguistic script in A. Pushkin's verse "Prophet".

<table>
<tr><th>Input</th><th colspan="2">EDUCATIONAL PROCESS</th><th>Output</th></tr>
<tr><td rowspan="2">Readiness for education and upbringing</td><td colspan="2"></td><td rowspan="2">Results of educational process</td></tr>
<tr><td>Non-verbal phase of teaching dialogue</td><td>Verbal phase of teaching dialogue</td></tr>
<tr><td rowspan="2">Receptive intention, practical communicative need («With fainting soul athirst for Grace'...»)</td><td>I. Teaching:
1) invention
2) disposition
3) elocution</td><td rowspan="2">God's word as inspiring psychoenergetic impulse («Arise, and let My voice be heard ...»)</td><td rowspan="2">Prophet, Messiah, Supreme Linguistic Personality</td></tr>
<tr><td>II. Upbringing:
«My quaking heart thereout he reft – A coal of living fire»</td></tr>
</table>

The advantages of the L&R methodology consist in combining the linguistic and literary approaches with the latter deriving from rhetoric [14]. The three strands in textual linguistics – textual proper, syntactical, and stylistic – can also be united under the L&R auspices due to its more general character. Schematically, textual categories [15] manifest themselves at the sign level in implicit discourse-building triads. Informativity, continuum, and autosemantics are determined by the integration of logos, thesaurus and invention; integration, division and completion rest on ethos, motivation and disposition; cohesion, retrospection and prospection organize the elocution at the level of the verbal semantic network, creating an aura of pathos.

The delimitation of a text can be invention-based, disposition-directed and elocution-ornamented. Integration as a subordination of textual elements to the most general idea of the whole text is perceived as a manifestation of the inventive core of an utterance; continuum, i.e. a chain of dependencies deriving from the logic of relations among textual components, is a form of the existence of the inventive dispositional framework; chaining, i.e. the syntagmatic linking of the related sentences, is the elocutionary level phenomenon. At the elocutionary level the three planes of textual modality – subjective modal, emotional semantic and functional orientational [16] – constitute the continuum of discourse-text, creating 'narration shifts' which indicate the author's implicit presence.

The final outcome of the productive receptive dialogue is the sense of a literary work generated by a linguistic personality, namely, artistic aesthetic, ethical, cognitive, or in other words, the textual elements related to the truth, the good, the beauty, and history, i.e. "its intention, the aim of its creation" [17].

The L&R dynamicity of the thinking and speaking process in the linguistic personality^{1} *sphere* goes through the following stages: the formation of the indivisible ***sense***^{1} which can be signaled by a corresponding emotional state, for instance, a feeling of 'a bitter brew' (O. Bergolts); self-deployment of the intention, specification of the sense in its relation to the reality of the perceived world in the ***contents***^{1} and formation of its inventive dispositional framework in the inner speech; verbalization in the external speech and the compression of the ***meaning***^{1} at the textual level.

Hermeneutic dynamicity of speaking and thinking process in the sphere of linguistic personality^{2} is generated in the reverse order*:* meaning^{1} transforms into meaning^{2}, then into contents^{2} and then into sense^{2} through the tunnel of culture concepts providing for specific communication due to the psychoenergetic superimposition of the semantic cores of cultural

concepts of linguistic personality[1] and those of linguistic personality[2] depending on the individuality of each "concept bearer" (see [18]).

The elocutionary expressive aspect of L&R interpretation and functional metabolic interactions in particular, appear to be a generative substance of a text. Alongside the regular grammatical and stylistic neutral figures, metabolas as expressive speech gestures [19] are included into a broader notion of "figure of speech". The latter appears to implement, explicate and transform linguistic functions. Being specific devices of thinking and speaking activity of a literary personality, figures of thought and tropes penetrate all the stages of the idea-into-speech transformation cycle. Syntactic figures constitute the field of elocution proper since being direct signs of emotions they are embodied in the language units explicating the internal state of a literary personality. The particular markers of the syntactic – partially neutral grammatical – figures of speech are function words. At the paragraph level anaphoric relations serve as elocutionary signals of inventive dispositional framework of a text creating its specific rhetorical publicistic tone.

Conclusion. The article demonstrates the explanatory potential, the creative role and the methodological status of L&R paradigm. Within the framework of studying the conceptual models and mechanisms of the linguistic consciousness in the East Slavic and Western discursive processes it seems especially important to explore the transformation of the national consciousness in sociocultural and cognitive contexts of modern Russian, Ukrainian, British and American societies as well as the aspects of their L&R embodiment in discourse and text with a special attention to the belletristic and media communication. The results of the investigations from the L&R paradigm perspective are reflected in a number of works [20–23].

Примечания:

1. Ворожбитова А.А., Кузнецова Л.Н. Лингвориторика дискурсивных процессов: типология интертекстуальных включений в научно-интерпретативном дискурсе филолога как профессиональной языковой личности // Известия Сочинского государственного университета. 2012. №3 (21). С. С. 182–186.
2. Безменова Н.А. Очерки по теории и истории риторики. М.: Наука, 1991. С. 43.
3. Михальская А. К. Риторика // Педагогическое речеведение: Словарь-справочник. М., 1998. – С. 203.
4. Топоров В.Н. Риторика // Лингвистический энциклопедический словарь / Под ред. В.Н. Ярцевой. Изд. 2 доп. М.: Большая Русская Энциклопедия, 2002. С. 417.
5. Ворожбитова А.А. Лингвориторическая парадигма: теоретические и прикладные аспекты: Монография. Сочи: СГУТиКД, 2000.
6. Львов М.Р. Риторика. Культура речи: Учеб. пособие для студ. высш. учеб. заведений, обуч. по пед. спец. 2-е изд., испр. М.: Издательский центр «Академия», 2004.
7. Караулов Ю.Н. Русский язык и языковая личность. Изд. 2-е, стереотипное. М.: Едиториал УРСС, 2002. 264 с.
8. Ворожбитова А.А. Лингвориторическое образование как инновационная педагогическая система (принципы проектирования и опыт реализации): Монография. 2-ое изд. испр. и доп. М: ФЛИНТА, Наука, 2013. 312 с.
9. Гаспаров Б.М. Язык, память, образ. Лингвистика языкового существования. М., 1996.
10. Леонтьев А.А. Надгробное слово «чистой» лингвистике // Лингвистика на исходе XX века: итоги и перспективы. Тезисы международной конференции. Т.II. М., 1995. С. 307–308.
11. Язык – система Язык – система. Язык – текст. Язык – способность. Сб. статей / Институт русского языка РАН. – М., 1995.
12. Жаналина Л.К. Язык и речь: оппозиции // Филол. науки. 1996. № 5. С. 57.
13. Швейцер А.Д. Социолингвистика // Лингвистический энциклопедический словарь. М., 2002. С. 481.
14. Гаспаров М.Л. Античная риторика как система //Античная поэтика: рито-ическая теория и литературная практика. М., 1991. С. 27–59.
15. Гальперин И.Р. Текст как объект лингвистического исследования. М.: КомКнига, 2007.
16. Ильенко С.Г. Синтаксические единицы в тексте. Л., 1989.
17. Бахтин М.М. Проблема текста. Опыт философского анализа // Вопросы литературы. 1976. № 10. С. 122–151.
18. Лихачев Д.С. Концептосфера русского языка // Русская словесность. Антология. М., 1997. С. 280–287.
19. Дюбуа Ж. и др. Общая риторика. М.: КомКнига, 2006.

20. Ворожбитова А.А. Сочинская лингвориторическая школа: программа и некоторые итоги // Вестник Северного (Арктического) федерального университета. Серия: Гуманитарные и социальные науки. 2011. № 1. С. 77–83.
21. Ворожбитова А.А. Теория и практика лингвориторической парадигмы: Сочинская школа // Вестник Российского университета дружбы народов Серия, «Вопросы образования: языки и специальность». №4. 2012. С. 77–84.
22. Потапенко С.И. Сочинская лингвориторическая школа как коллегиальный субъект исследования дискурсивных процессов // European Journal of Contemporary Education, 2013, Vol.(5), № 3. p. 162–172.
23. Ренз Т.Е. Концептуально-технологическое обеспечение организации и проведения Международной научной школы «Лингвориторическая парадигма: теоретические и прикладные аспекты» // European Journal of Contemporary Education, 2012, Vol.(1), № 1. С. 40–47.

References:

1. Vorozhbitova A.A., Kuznecova L.N. Lingvoritorika diskursivnyh processov: tipologija intertekstual'nyh vkljuchenij v nauchno-interpretativnom diskurse filologa kak professional'noj jazykovoj lichnosti // Izvestija Sochinskogo gosudarstvennogo universiteta. 2012. №3 (21). S. 182–186.
2. Bezmenova N.A. Ocherki po teorii i istorii ritoriki. M.: Nauka, 1991. S. 43.
3. Mihal'skaja A. K. Ritorika // Pedagogicheskoe rechevedenie: Slovar'-spravochnik. M., 1998. S. 203.
4. Toporov V.N. Ritorika // Lingvisticheskij jenciklopedicheskij slo-var' / Pod red. V.N. Jarcevoj. Izd. 2 dop. M.: Bol'shaja Russkaja Jen-ciklopedija, 2002. S. 417.
5. Vorozhbitova A.A. Lingvoritoricheskaja paradigma: teoreticheskie i prikladnye aspekty: Monografija. Sochi: SGUTiKD, 2000.
6. L'vov M.R. Ritorika. Kul'tura rechi: Ucheb. posobie dlja stud. vyssh. ucheb. zavedenij, obuch. po ped. spec. 2-e izd., ispr. M.: Izdatel'skij centr «Akademija», 2004.
7. Karaulov Ju.N. Russkij jazyk i jazykovaja lichnost'. Izd. 2-e, stereo-tipnoe. M.: Editorial URSS, 2002. 264 s.
8. Vorozhbitova A.A. Lingvoritoricheskoe obrazovanie kak innovacion-naja pedagogicheskaja sistema (principy proektirovanija i opyt reali-zacii): Monografija. 2-oe izd. ispr. i dop. M: FLINTA, Nauka, 2013. 312 s.
9. Gasparov B.M. Jazyk, pamjat', obraz. Lingvistika jazykovogo sushhestvo-vanija. – M., 1996.
10. Leont'ev A.A. Nadgrobnoe slovo «chistoj» lingvistike // Lingvistika na ishode HH veka: itogi i perspektivy. Tezisy mezhdunarodnoj kon-ferencii. T.II. M., 1995. S. 307–308.
11. Jazyk – sistema Jazyk – sistema. Jazyk – tekst. Jazyk – sposobnost'. Sb. statej / Institut russkogo jazyka RAN. M., 1995.
12. Zhanalina L.K. Jazyk i rech': oppozicii // Filol. nauki. 1996. № 5. S. 57.
13. Shvejcer A.D. Sociolingvistika // Lingvisticheskij jenciklopediche-skij slovar'. M., 2002. S. 481.
14. Gasparov M.L. Antichnaja ritorika kak sistema //Antichnaja pojetika: rito-richeskaja teorija i literaturnaja praktika. M., 1991. – S. 27–59.
15. Gal'perin I.R. Tekst kak ob#ekt lingvisticheskogo issledovanija. M.: KomKniga, 2007.
16. Il'enko S.G. Sintaksicheskie edinicy v tekste. L., 1989.
17. Bahtin M.M. Problema teksta. Opyt filosofskogo analiza // Vopro-sy literatury. 1976. № 10. S. 122–151.
18. Lihachev D.S. Konceptosfera russkogo jazyka // Russkaja slovesnost'. Antologija. M., 1997. S. 280–287.
19. Djubua Zh. i dr. Obshhaja ritorika. M.: KomKniga, 2006.
20. Vorozhbitova A.A. Sochinskaja lingvoritoricheskaja shkola: programma i nekotorye itogi // Vestnik Severnogo (Arkticheskogo) federal'nogo universiteta. Serija: Gumanitarnye i social'nye nauki. 2011. № 1. S. 77–83.
21. Vorozhbitova A.A. Teorija i praktika lingvoritoricheskoj paradigmy: Sochinskaja shkola // Vestnik Rossijskogo universiteta druzhby naro-dov Serija, «Voprosy obrazovanija: jazyki i special'nost'». №4. 2012. S. 77–84.
22. Potapenko S.I. Sochinskaja lingvoritoricheskaja shkola kak kollegi-al'nyj sub#ekt issledovanija diskursivnyh processov // European Journal of Contemporary Education, 2013, Vol.(5), № 3. p. 162–172.
23. Renz T.E. Konceptual'no-tehnologicheskoe obespechenie organizacii i provedenija Mezhdunarodnoj nauchnoj shkoly «Lingvoritoricheskaja paradigma: teoreticheskie i prikladnye aspekty» // European Journal of Contemporary Education, 2012, Vol.(1), № 1. S. 40–47.

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Making Room for Gender Sensitivity in Pre-Service Teacher Education

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Abstract. Education is an effective tool for effecting change both on an individual and social level and it is a key institution that can minimize the differences among social groups and genders. While teachers are key actors responsible for implementing this basic function of education, they themselves are raised in societies that are stratified by gender. Teachers act as carriers of the values and cultural codes of their societies and have a tendency to support students' opinions and behaviours and educational and professional choices shaped by sexist stereotypes, thereby contributing to inequality. Therefore, one strategy to adopt in combating inequality between genders is to raise awareness and sensitivity of teachers concerning gender inequality. With this strategy in mind, this study seeks to identify the key features of Gender Equality course for pre-service teachers in Turkey.

Keywords: Sexism; gender training; gender sensitivity; teacher education.

Introduction

Children learn to adopt and internalize the roles expected from their sex at an early age, during the preschool socialization process, and in different ways (such as through observation, modelling, being rewarded or penalised). By the time they start school, they are already equipped with gender-based thoughts and behaviours. Schools carry new and original effects that reinforce the sex role patterns adopted in the family. Teachers also play a key role in the reproduction of gender inequality in instructional practices and school life.

Studies on how gender stereotypes are acquired or reinforced in educational processes feature two varying views about the role of teachers in this process. According to one view, teachers have only passive roles in making children acquire gender stereotypes and sexist attitudes as children already acquire them before they start to attend school (Eccles & Blumenfeld, 1985). As is known, gender role socialization cannot be isolated from the general socialization process. In this framework, children are actually socialized in accordance with gender stereotypes from the moment they are born. Stereotypes are learned particularly in the family. Accordingly, schools and teachers should adopt a neutral attitude and give children the freedom to make their gender choices (Eccles & Blumenfeld, 1985). According to the second view, children are still forming their perceptions of gender when they start school and will continue to do so throughout their education. Like families, schools are settings where specific understandings about gender roles and gender

relations develop and take hold. Although these stereotypes begin to be acquired by students in their preschool years, teachers, despite their secondary roles, tend to do little in making students rethink their beliefs about these stereotypes. Mostly, it is seen that they ignore the influence of sexist stereotyping in shaping students' educational and professional choices, thereby contributing to inequality. However, teachers also have primary responsibility for directing students to question sexism in their norms and values (Eccles & Blumenfeld, 1985; Streitmatter, 1994). Therefore, teachers, as agents of change, should combat gender stereotypes that are acquired in preschool years, help students to limit the restrictions of traditional society, and realize that they are equal citizens (Gray & Leith, 2004; Sayman, 2007; Streitmatter, 1994). According to this perspective, for teachers to become effective agents of change, they should receive training in gender equality and associated instruction strategies during their professional training (Baba, 2007; Owens, Smothers & Love 2003).

This approach is frequently reiterated in all international documents and texts that seek to develop policies concerning women and, in particular, it is considered as a basic strategy for underdeveloped and developing countries where gender inequalities are more frequent. The 7th Council of Europe Conference of Ministers responsible for Equality between Women and Men recommended that teachers should be made aware of sexist stereotypes in order to combat stereotypes in education, noting that teachers tend to believe girls or boys are successful in specific courses and that the awareness-raising efforts that target teachers and other education personnel should be encouraged for combating this and similar stereotypes (Council of Europe, 2007).

In recent years, the Turkish education system has also set out to make teachers aware of gender equality and gender sensitivity. In order to improve gender equality in various aspects of men and women's lives in Turkey, the General Directorate on the Status of Women (GDSW) that is affiliated to the Ministry of Family and Social Policies prepared the Gender Equality National Action Plan for 2008-2013. According to the national goals identified under the "education" subtitle of this policy document, educators, educational programs and materials will be required to be gender sensitive (GDSW, 2008). The measures for so doing were identified as follows:

- To integrate the issue of gender equality across the entirety of undergraduate and postgraduate courses on offer at Faculties of Education in Turkey.
- To provide Gender Equality Sensitivity Training to in-service teachers.
- To review and amend accordingly all content pertaining to education and training programmes, methodologies, learning materials and instructional aids, so that they are gender sensitive.
- To introduce the issue of gender equality to all formal and informal education settings and continue to support the drive for gender equality through life skills courses at all levels of learning.

The Ministry of Education, the GDSW and the Council of Higher Education are tasked with implementing these measures, which are clearly meant to have a strategic impact on Turkey's institutions and academic practices.

This study aims to stress the importance of boosting teachers' gender sensitivities and to discuss various proposals about a curriculum that can be applied at the national level in Turkey. To this end, first, a framework that helps us to understand how teachers reproduce gender inequalities will be briefly presented. Then the national and international situation on gender equality training will be discussed, and finally, a course proposal for teacher training institutions will be described.

The Reproduction of Gender Inequality in the Classroom Climate: The Role of the Teacher

The tradition of questioning the reproduction of patriarchal ideology in the education system and instructional processes in Turkey gained ground after the 1970s. Having accelerated since the second half of the 1990s when women's studies became established as an academic field, we have seen how feminist educational studies have contributed to the formation of a national literature, particularly on how curricula and course books reproduce gender discrimination. Other than course books and curricula, there is unfortunately a shortage of in-depth research in Turkey that focuses on sexist ideas and behaviour patterns reproduced by school cultures, classroom climates, and their relationships and actors. Thus, there is a lack of detailed national empirical data particularly concerning the reproductive roles of teachers within this structure. Despite the lack of research in Turkey, the international literature shows that school life and culture reproduces asymmetrical gender power relations in various ways. Schools and teachers have a key role in how

children construct and code gender through classroom practices, language, expectations and behaviours, and values system and attitudes (Younger & Warrington, 2008). Schools shape/socialize students via the official and hidden curriculum, in other words through behaviour codes, classroom organization and the informal pedagogical methods used by teachers (i.e., discipline and punishment methods, etc.). Gender emerges as an important organizational/administrative category in all stages of the educational system (from preschool to higher education). In traditional schools, there is a strong relation between the definitions of masculinity and femininity, which is supported by the spatial organization of the school, school uniforms, classroom activities and the curriculum (Arnot, 2002). For instance, girls and boys are usually segregated into different areas within the same school building, and their play areas and objects, classroom seating, responsibilities and so on are generally determined by their gender (Delamont, 1990; Gray & Leith, 2004).

Sadker and Sadker (1986) define schools as places that systematically reproduce gender inequality. Girls and boys who sit in the same classrooms, study the same course books and listen to the same teacher can still receive a rather different education. In all stages of education, girls are the invisible members of the classroom. Teachers interact more with boys, ask them better questions, and give them more valuable and helpful feedback. While girls learn to wait in patience, boys learn that they are the main actors of class life (Sadker, Sadker & Zittleman 2009).

Studies on classroom interaction models have shown that the school climate encourages female students much less than their male counterparts to participate in curricular and extracurricular activities. Findings of previous studies have shown that teachers are more involved with male students in the classroom, support them more, put them in the spotlight especially in science and math classes, ignore female students, and prevent them from speaking their minds and improving their verbal skills (Eccles & Blumenfeld, 1985; Stanworth, 1990; Streitmatter, 1994; Li, 1999; Duffy, Warren & Walsh, 2001; Tsouroufli, 2002; Smith, Hardman & Higgins 2007). Further, even when a difference does not exist between male and female students' math scores, teachers report that males are more successful (Tiedemann, 2002). A study conducted in Turkey similarly concluded that teachers find boys more successful in math, physics and sports, while they find girls more successful in verbal fields and music (Baç, 1997).

Regarding tasks and responsibilities, female students are mostly put in charge of classroom cleanliness and spatial organization, while boys are given tasks that require more responsibility such as taking care of materials and equipment, or manage the classroom and ensure discipline when the teacher is not there (UNESCO, 2004). Teachers' expectations from their students and the way they interpret student behaviours also vary with respect to gender. They normally expect girls to be polite, respectful, conscientious, helpful, eager to please, obeying without question (Robinson, 1992) or hard-working, rule-following, cooperative, conscientious and academically able (Renold, 2006). The adjectives teachers use to define their students are parallel to their expectations. For instance, the Turkish teachers who participated in Baç's (1997) study used the adjectives 'adventurous, reckless, aggressive, active, and intelligent' for boys and 'tidy, quiet, sensitive, respectful, and reliable' for girls. In addition, teachers seem to be more tolerant of resistant behaviours such as 'asking irrelevant questions' or 'disrupting class' which are mostly displayed by boys who are defined as 'dominant, disruptive, underperforming and generally challenging' (Sadker&Sadker, 1985; Robinson, 1992; Renold, 2006).

Rich scientific data about the classroom climate shows that teacher behaviours, attitudes, actions and words discourage girls in different ways and affect their self-confidence adversely. Similar to many other countries, Turkish girls have better academic success and higher learning motivation than boys. However, when one is to participate in the lesson, discuss an issue or speak out, a teacher or a male student can easily break the spirit of female students (Sayan, 2007). Such blows to girls' brevity and self-confidence may affect not only their educational development but also their career/professional choices (Bailley, 1993; Duffy et al., 2001). Teachers are also known to influence students' career plans and decisions, and particularly encourage girls who choose a male dominant work field (Streitmatter, 1994). As shown in several studies such as that of Baç (1997), however, on the whole teachers see professions related to power and merchandise as fit for boys, and those requiring caring, domestic work, verbal ability and physical presentation as fit for girls.

Tan (2007) showed in her study that the most important actors of sexism in instructional processes in Turkey were teachers. According to the results of this study, teacher expectations and

behaviours particularly reinforce gender discrimination among high school students, encourage them to choose certain professions and gender roles, and control their sexuality. These negative influences are valid for teachers of both sexes. Tan lists teachers' sexist behaviours as follows: Interfering with students' appearance and clothing, blaming them for befriending the opposite sex, not allowing girls to talk during in-class discussions or ignoring their questions, planning course content in relation to gender, seating girls and boys separately in the classroom, choosing members of one sex for classroom leadership, cleaning, or tasks such as carrying things (Tan, 2008). These start as early as the preschool period, and continue both explicitly and implicitly even at university when students have become adults.

Teachers, the backbone of instructional practices, are also born into societies shaped by gender roles and thus also become carriers of the values and cultural codes of their own societies. Teachers may not openly discriminate between the two sexes in their classrooms but their expectations, instructional and discipline methods are directly related to their gender-biased attitudes and behaviours (Streitmatter, 1994). In other words, the differences in teacher behaviours towards girls and boys, the interaction styles they use with them, and the roles and responsibilities they give them are generally determined by a patriarchal worldview that preserves the hierarchical structure between the sexes (Robinson, 1992; Arnot, 2002; UNESCO, 2004; Tan, 2008).

According to UNICEF's report (2003), A Gender Review in Turkish Education, the social environment that teachers grow up in and their ways of socialization and education often precludes them from questioning gender inequality. Teachers ignore whether schools are patriarchal places and thus pay no attention to sexist approaches and the conservative or sexist content of course books. Female teachers too are gender blind like their male counterparts; they are largely insensitive about directing students to traditional gender roles and reinforcing sexism. According to Torun's (2002) study, even though gender stereotypical thoughts and beliefs play a crucial role in the teacher-student interaction, neither teachers nor students are aware of this. The fact that teachers are not aware of, question or care about gender discrimination shows that they too have internalized the traditional viewpoint regarding gender (UNICEF, 2003).

Gender Training: A Conceptual Framework

The concept 'gender' stresses that inequality between women and men stems not from biological differences, but from social and cultural contexts, which can be transformed through various strategies. The aim of this transformation is to attain gender equality, i.e., ensuring that no one suffers from inequality or discrimination due to his/her gender (UNDP, 2001). Being one of the main strategies that can be wielded in attaining this aim, gender education is an activity of enhancement that seeks to create awareness, knowledge, skills and behavioural change about gender (UNESCO, 2000).

Training implemented with the aim of fostering the gender equality mindset generally intends to make individuals acquire two basic skills. The first of these is gender sensitivity that is defined as the skill of acknowledging the differences between genders as well as problems and inequalities associated with these differences, bringing them into view and incorporating them into strategies and actions (UNDP, 2001; UNESCO, 2010). Gender sensitivity is considered as the starting point for gender awareness. Gender awareness is a more critical and exacting understanding of the fact that differences between sexes - which affect individuals' skills for accessing and controlling resources and services - are dependent on acquired behaviours (UNESCO, 2010). Gender awareness is the ability to detect, even when they are not salient, the problems stemming from gender inequality and discrimination (USAID, 2007). This awareness entails gender mainstreaming.

In this conceptual framework, a gender education activity to be designed for teachers has the potential to trigger the intended social change about gender equality. This is because teachers are positioned as strategic agents of change as they function as role models with their attitudes, methods and practices inside and outside the classroom. Therefore, teachers should be able to diagnose sexist stereotypes and biases, i.e. the inequality-producing structure of the society in which they live, and then to recognize in their individual and professional lives the beliefs, behaviours and attitudes that reproduce this structure. To this end, they need to undergo special sensitivity and awareness training.

The Gender Agenda in Teacher Education

One of the major problems related to teacher training programs on a global scale is the lack of courses that focus on the gender issue. Both in developed and underdeveloped countries, the institutions that train teachers are still undecided about organizing courses, seminars or workshops on gender equality as part of their teacher training programs (Gaudet & Lapointe, 2002; Gudbjornsdottir, 2012). Various studies on teachers and teacher trainers reveal there is no systematic education focus on gender neither in pre-service nor in-service settings despite the global emphasis on the importance of the gender issue (The American Association of University Women, 1999; Cushman, 2010; Knipe, Leith, Gray, McKeown & Carlisle, 2002; Malmgren & Weiner, 2001; Weiner, 2000; Younger & Warrington, 2008; Buchberger, Campos, Kallos & Stephenson, 2000).

The sufficiently intensive curricula, used in teacher training institutions, are identified as one of the reasons for this. The proponents of this approach argue that it is not easy to integrate the gender equality perspective with a number of areas that teachers deal with such as design, content and teaching approach (Oxfam, 2004). Moreover, in the US, gender is treated as part of the courses on diversity and multiculturalism and, therefore, some argue there is no need to develop a special course on this matter (Weiner, 2000). Thus for most teacher trainers, gender remains a low-priority issue. Coupled with other factors, this results in a general lack of gender discourse in the teacher training area (Weiner, 2000).

However, special efforts to fill this gap through gender education seminars, elective courses and workshops with pre-service teachers, in-service teachers and teacher trainers have reportedly produced quite successful results (Allana, Asad & Sherali, 2010; Kawana, 2009, Sanders, 1996). Studies indicate that gender education creates in participants a more flexible gender role orientation, and reinforced sense of control and self-respect in their lives (Haris, Melas & Rodacker 1999). Moreover, those who attended these training courses tend to develop consciousness/awareness about sexism and other social inequalities, and acquire self-respect/self-confidence and motivation for social activism and develop more egalitarian attitudes toward women and other oppressed groups (Stake, 2006; Stake & Hoffmann, 2001).

Currently, the curricula of higher education institutions that prepare teachers in Turkey do not include special courses on the gender issue. There are efforts to tackle this deficiency by introducing some elective courses or incorporating gender content into some compulsory courses at some universities. For instance, Erden (2009) reported favourable changes in the attitudes of pre-service teachers who attended her elective course on gender equality. Another study conducted by Esen (2013) found positive changes in the pre- and post-training levels of sensitivity and awareness of pre-service teachers after gender education was incorporated into a compulsory course. According to the results of this study the most striking difference after the training emerged when participants began to question whether or not to conform to the values of the traditional patriarchal society and how to apply their gender awareness to the professional domain. Esen showed in her study that as a result of a systematic study of gender issues, prospective teachers were able to question traditional value judgments and to gain motivation for personal change/transformation in their own lives and settings.

Elsewhere some private institutions in Turkey have begun to implement gender training as seen in the Sabancı University project group tasked with "educating the educator". This initiative has produced a certificate programme for in-service teachers, which includes the following gender specific aims: - To establish gender studies tasked with helping to instil best practice throughout the Turkish high school education system and its various extra-curricular activities. – To encourage the adoption of such practices so that teachers routinely foster in their students appropriate behaviour towards women and awareness of their rights. – To adjust and sensitise the language of programme participants so that they can readily express and advance gender equality at school. – To utilise a pragmatic and personalised "learning to learn" approach to gender equality in the classroom, one that empowers and sustains high school teachers to implement gender sensitive education.

One of the reports discussed during the 2008-2013 Gender Equality Action Plan Monitoring and Evaluation Meeting organised by the GDSW (2011) was entitled "Women and Education." This provides information about the progress made in Turkey concerning the targets and strategies set forth in the Action Plan. Examination of the report indicates that significant efforts are being

undertaken within the Ministry of Education (ME) through various campaigns and projects, for instance, the "Mothers and Daughters at School" Anti-illiteracy Campaign, projects for boosting the schooling rate of girls, a project for Supporting Gender Equality in Education, the Conditional Education Aids, etc. Moreover, a Gender Equality Commission was set up as part of the Education and Discipline Department of the ME with a view to removing sexist language, images, expressions and similar elements that are portent of gender discrimination as well as gender stereotypes from curricula, course books and other educational materials. The report detailed how the ME had been undertaking significant work in terms of policies and practices for ensuring gender equality in recent years.

Yet, the prime responsibility for implementing these policies and practices falls on the shoulders of teachers and school administrators. If the policies designed to ensure gender equality are not realised in school and in-classroom processes, it will be impossible to attain the specified targets. In this regard, the revision of policies applicable to teacher training by the Council of Higher Education should be implemented as soon as possible. Several initiatives were launched to insert the gender equality vision into curricula in four basic areas (education, media, health and law) with the aim of creating gender awareness in higher education course contents, but the continuation of these initiatives is uncertain. Thus, concrete steps are yet to be taken with regards to one of the most important strategies in the Action Plan, i.e. ensuring that education faculties offer undergraduate and graduate programs concerning gender equality.

Gender Equality Sensitivity Training for Undergraduate Programs of Faculties of Education: A Course Proposal

Mindful of the positive and negative developments concerning gender education in Turkey, we have considered a framework for a "Gender and Education" (GE) course that can be inserted as a compulsory or elective course within the curricula of education faculties. The purpose of this effort is to establish curriculum or module development on this subject.

Target Group: Students who are attending an education faculty and professional teachers via in-service training.

General Purpose of the GE Course: To boost course attendants' gender sensitivity and awareness. In other words, the overall goal of this course would be to improve pre-service teachers' existing knowledge and conceptions about gender inequality and to help ensure that they put into practice their potentials for combating this inequality in their social and professional spheres. The sub-goals of the course regarding knowledge, skills and attitudes can be summed as follows:

- The knowledge aspect: The GE course should provide participants with knowledge on gender inequality, implicit/explicit discrimination, stereotypes/prejudices as a form of discrimination, and the potential of the school culture for reproducing gender inequality.
- The skills aspect: The GE course should endow participants with skills for recognizing stereotypes in social and cultural patterns, and written and visual materials, particularly in their own lives. On a professional level, it should assist participants to identify gender inequality in their curricula, education materials and methods, and interaction processes in the classroom. Thereby helping them to detect gender inequality interference in social and professional processes.
- The attitudes aspect: The GE course should engender the empathy of participants for individuals and groups who suffer from discrimination. It should also foster determination for improving gender equality, the belief that individual efforts can make a difference, and enable participants to adopt critical perspectives about stereotypes.

Learning Attainments of the Course: In this context, it is of importance to identify the skills and attitudes which participants are expected to develop as well as the information to be used in the process. In other words, the attainments of the GE course should be discussed at the knowledge, skills and attitude levels from a general perspective. The course should enable participants to competently:

1. Explain the significance of gender equality from a human rights perspective;
2. Recognize that gender inequalities do not stem from biological differences, but from discriminatory perspectives in their society and culture;
3. Exemplify the perspective they have acquired about gender equality in their own lives;
4. Discuss causes and effects of gender inequality in a local and universal setting;

5. Propose solutions to potential problems they may encounter in future by using the perspective they have acquired about gender equality;

6. Acknowledge that the views that are based on gender biases and stereotypes are an obstacle to gender equality;

7. Recognize the importance of advocating gender equality; and

8. Assume responsibility for positively transforming views that are based on gender biases and stereotypes.

Content of the Course: Course materials and activities should facilitate the learning attainments with emphasis on:

1. The meanings of the terms sex and gender,

2. The acquisition of sex and gender roles during socialization (the influence of the family, peer groups, TV, schools, etc.),

3. Gender stereotyping in the context of cultural/social values,

4. Discrimination between sexes in various areas in social life (in daily life, in human relations, in working life, etc.),

5. Gender in the context of educational processes and school culture,

6. The transformative role of schools and teachers in attaining gender equality (implementation of gender-friendly policies and strategies), and

7. Ways and methods for creating a gender-friendly classroom.

The practices to be developed within the scope of the last item are particularly important for pre-service teachers. First of all, gender equality in the classroom is a key that binds training and citizenship to human rights. On the other hand, gender equality in pedagogical practices affects the very nature of learning experiences of both girls and boys, thereby emerging as the central component not only of a quality education, but also of a better standard of living. For these reasons, the quest for attaining gender equality should be regarded as a fundamental human rights issue (Oxfam, 2004).

Teaching Methods and Techniques: Participants should be provided with a theoretical/conceptual framework with the foregoing headings in mind and at the same time, applied practices should be conducted. During this exercise, the mere presentation of descriptions or explanations about the topic should be carefully avoided or least used by the facilitator. This is because given the goals, attainments and contents, such a course should be able to position participants at the centre as much as possible. The knowledge acquired in the classroom should pave the way for participants' making sense of the real conditions related to their daily lives (Shor, 1980). To do this, the learning processes used should feature affinity to the daily lives of participants and rely on their intellectual, emotional and cultural resources, i.e., life-oriented knowledge should be placed at the centre.

In this context, those methods and techniques that would ensure active participation such as dramatization, classroom debate and opinion development, should be included in the teaching/learning process in the classroom setting. For instance, the drama technique can be used to find out how our and others' sexist views, attitudes and behaviours are reflected in our daily lives and educational processes. A case study about violence against women, a widespread social problem, may be made. The forms of reproduction of sexism in the media may be discussed with reference to advertisements and TV series.

Learning Resources for the Course: The learning resources for this course should mainly include books, academic research, and institutional reports. In addition, special emphasis should also be placed on internet resources, visual materials (short films, documentaries, newspaper clippings, etc.), and expert views about the subject matter.

Assessment Criteria for the Course: Given the objectives, attainments sought and context of this course, it is clear that traditional measurement and assessment approaches (written tests, etc.) will not apply. A significant part of the process is to orient participants toward applied practices where they make active use of their attainments and to encourage them to come up with various products. For instance, participants may conduct small-scale research using scientific research techniques (survey, interview, observing participants, etc). They may also conduct interviews or shoot spot films or design banners and posters about a specific social problem of interest within the scope of gender inequality.

Conclusion and Suggestions

Education is the main driver for triggering social change on gender equality. Although educational policies advocate gender equality in education, equality cannot be attained unless these policies enable teachers to perform a decisive role. In this sense, one of the best strategies is to equip teachers with sensitivity and awareness about gender equality. As they establish face to face and close relationships with students, teachers may play a major role in the development of new criteria, roles and attitudes regarding gender equality (Frawley, 2005). The resistance and new in-class strategies that teachers develop at the micro level against gender inequality may be used to change/transform gender-based layering. The most important way of realizing this is for teacher education policies to include gender sensitivity in the definition of a "high quality teacher" and ensure that teacher education institutions treat this concept in compulsory courses.

A few studies conducted at education faculties in Turkey found that even a brief training session on gender helped participants to start to question traditional value judgments and acquire a motivation for change/transformation, starting from their own lives (Esen, 2013) and attain positive attitudes (Erden, 2009). Furthermore, it was reported that gender education was able to create new forms of awareness and sensitivity or help participants to attain skills for supporting existing forms of awareness and sensitivity with a conceptual framework. In conclusion, training pre-service teachers about gender equality clearly is important and can make a difference. Yet, it is hard to suggest that the positive opinion and attitude changes this training will create during the pre-service period will be maintained in the long run (Erden, 2009). Therefore, instead of focusing on the efforts that would create one-time awareness, teachers should be supported with in-service training activities for sustainable gender sensitivity (Chisholm & McKinney, 2003). These activities should help teachers to develop practical solutions, accompanied by monitoring and follow-up support. Pre-service educational institutions and in-service professional development providers should be maintained in coordination with each other and these activities should be systematically documented. Moreover, exercise-centred materials should be prepared for teachers and networks should be established for encouraging teachers to conduct joint work on new pedagogical approaches (Oxfam, 2004).

The discussion about the existing structures and programs of teacher training faculties should be updated as well. Indeed, given the teaching methods and course books used in teacher training institutions and the attitudes of the academics working at these institutions, teacher education has been seen to reproduce the male-dominated structure (Lumadi & Shongwe, 2009; Zittleman & Sadker, 2002). It is a regrettable shortcoming that teacher training processes in Turkey have not been studied from this angle. In this context, it would be a major step to reinforce and support gender perspective in the research traditions of educational sciences and organize seminars to boost sensitivity among academics of education faculties. Tasks that can be performed by education faculties include incorporation of gender equality into curricula, training academics who wish to study on this subject and development of relevant educational materials and modules.

References:

1. American Association of University Women Educational Foundation (1999). *Gender gaps: Where schools still fail our children*. Washington, DC. http://www. aauw.org /learn /research/ upload/GGES.pdf

2. Allana, A.; Asad, N. & Sherali, Y. (2010). Gender in academic settings: Role of teachers. *International Journal of Innovation, Management and Technology, 1* (4), 343-348. Retrieved from http://www.ijimt.org/papers/63-C053.pdf

1. Arnot, M. (2002). *Reproducing gender*. London: Routledge.

4. Baba, H. B. (2007). *Teacher candidates as the agents of change for a more gender equal society*. Unpublished master's thesis. The Graduate School of Social Sciences of METU.

5. Baç, G. (1997). *A study on gender bias in teachers' behaviours, attitudes, perceptions and expectations toward their students.* Unpublished master's thesis. Department of Educational Sciences, METU.

6. Bailley, S.M. (1993). The current status of gender equity research in American schools. *Educational Psychologist, 28* (4), 321-339.

7. Buchberger, F.; Campos, B.P.; Kallos, D. & Stephenson, J. (2000). *High quality teacher education for high quality education and training. Green paper on teacher education in Europe, Umea*. Retrieved from http://tntee.umu.se/publications/greenpaper/greenpaper.pdf

8. Chisholm, L. & McKinney, C. (2003). Reforms, innovations and approaches used to work with teachers to use them as change agents and facilitators of gender equality in different countries: Strengths and limitations. *Paper commissioned for the EFA Global Monitoring Report 2003/4, The Leap to Equality*, UNESCO. http://unesdoc.unesco.org/ images/ 0014/ 001467/146757e.pdf

1) Council of Europe (2007). *Recommendation CM/Rec (2007) 17 of the Committee of Ministers to member states on gender equality standards and mechanisms*. Retrieved from https://wcd.coe.int/ViewDoc.jsp?id=1215219&Site=CM

10. Cushman, P. (2010). Three men teachers, three countries and three responses to the physical contact dilemma. *International Journal of Education, 1* (1), 1-16.

11. Delamont, S. (1990). *Sex roles and the school*. London: Routledge.

12. Duffy, J., Warren, K. & Walsh, M. (2001). Classroom interaction: Gender of teacher, gender of student and classroom subject. *Sex Roles, 45* (9-10), 579-593.

13. Eccles, J.S. & Blumenfeld, P. (1985). Classroom experiences and student gender: Are there differences and do they matter? In L.C. Wilkinson ve C.B. Marrett (Eds.), *Gender influences in classroom interaction*. (pp.79-114). Orlando: Academic Press.

14. Erden, F. T. (2009). A course on gender equity in education: Does it affect gender role attitudes of preservice teachers? *Teaching and Teacher Education, 25*, 409-414.

15. Esen, Y. (2013). Hizmet öncesi öğretmen eğitiminde toplumsal cinsiyet duyarlılığını geliştirme amaçlı bir çalışma. *Eğitim ve Bilim, 38(169)*, 280-295.

16. Frawley, T. (2005). Gender Bias in the Classroom: Current controversies and implications for teachers. *Childhood Education 81*(4):221-27.

17. Gaudet, J. A. & Lapointe, C. (2002). What could an equitable instructional design achieve? An experiment with trainers. *New Horizons in Adult Education,16*(3), 13-26. Retrieved from http://education.fiu.edu/newhorizons/journals/volume16no3.pdf

18. General Directorate on the Status of Women. (2008). National Action Plan Gender Equality 2008-2013. Retrieved from http://www.kadininstatusu.gov.tr/upload/ kadininstatusu. gov.tr/mce/eski_site/Pdf/NAP_GE.pdf

19. General Directorate on the Status of Women. (2011). Toplumsal Cinsiyet Eşitliği Ulusal Eylem Planı İzleme ve Değerlendirme Toplantısı-2011. Retrieved from http://www.kadininstatusu.gov.tr/upload/kadininstatusu.gov.tr/mce/2012/uep_2011.pdf

20. Gray, C. & Leith, H. (2004). Perpetuating gender stereotypes in the classroom: A teacher perspective. *Educational Studies, 30* (1), 3-17.

21. Gudbjornsdottir, G. (2012). *Exchange of good practices on gender equality. Gender training in education, Portugal 18-19 October 2012*. Comments paper-Iceland. European Commission. Retrieved from http://ec.europa.eu/justice/genderequality/files/ exchange_of_ good_ practice_pt/pt_discussion_paper_pt_2012_de.pdf

22. Haris, K. L.; Melas, K. & Rodacker, E. (1999). The impact of women's studies courses on college students of the 1990s. *Sex Roles, 40 (11-12)*, 969-977.

23. Kawana, S. (2009). Gender and teacher education policy in Japan: Feminist teachers organising for change. *Electronic Journal of Contemporary Japanese Studies,3*. Retrieved from http://www.japanesestudies.org.uk/articles/2009/Kawana.html

24. Knipe, D.; Leith, H.; Gray, C.; McKeown, E. & Carlisle, K. (2002). *Betty the builder, Neil the nurse: Sex-typing of occupations in primary schools*. Belfast: Equality Commission for Northern Ireland. Retrieved from http://www.equalityni.org/sections/default.asp?secid =8vecms=Publications_Sex_research+reportsvecmsid=7_39_186veid=186

25. Li, Q. (1999). Teachers' beliefs and gender differences in mathematics: A review. *Educational Research, 41* (1), 63-76.

26. Lumadi, M. W. & Shongwe, S. S. (2010). The need for training gender-sensitive teachers: addressing challenges of gender sensitive education for gender sensitive national development. *Contemporary Issues In Education Research, 3 (3)*, 41-50.

27. Malmgren, G. & Weiner, G. (2001). Disturbing boundaries in teacher education: Gender and the 'F' word - feminism. *International Journal of Inclusive Education, 5* (2), 237-255.

28. Owens, S. L.; Smothers, B.C., & Love, F.E. (2003). Are girls victims of gender bias in our nation's schools? *Journal of Instructional Psychology, 30*(2), 131-136.

29. Oxfam. (2004). *Pedagogic strategies for gender equality: A beyond access project policy paper*. Retrieved from http://www.oxfam.org.uk/resources/issues/ education/ downloads/ba_strategies.pdf

30. Renold, E. (2006). Gendered classroom experiences. In C. Skelton, B. Francis ve L. Smulyan (Eds.), *The sage handbook of gender and education*. (pp.439-450). London: Sage.

31. Robinson, K.H. (1992). Classroom discipline: Power, resistance and gender. A look at teacher perspectives'. *Gender and Education, 4*(3), 273-288.

32. Sadker, M. P. & Sadker, D. M. (1985) Sexism in the schoolroom of the 80's. *Psychology Today,19*(3), 54–57.

33. Sadker, M.P. & Sadker, D.M. (1986). Sexism in the classroom: From grade school to graduate school. *The Phi Delta Kappan,* 67(7), 512-515.

34. Sadker, D.M., Sadker, M.P. & Zittleman, K.R. (2009). *Still failing at fairness: How gender bias cheats girls and boys in school and what we can do about it*. New York: Simon & Schuster.

35. Sanders, J. (1996). *Institutionalizing gender equity in teacher education*. Paper presented at the Annual Meeting of the American Association of Colleges for Teacher Education. Retrieved from http://eric.ed.gov/PDFS/ED392779.pdf

36. Sayan, S. (2007). *Kız öğrencilerin okul yaşantılarına ilişkin nitel bir araştırma.* Unpublished Master's Thesis. Institute of Educational Sciences, Ankara University.

37. Sayman, D. (2007). The elimination of sexism and stereotyping in occupational education. *The Journal of Men's Studies, 15*(1), 19–30.

38. Shor, I. (1980). *Critical teaching and everyday life*. Boston: South End Pres.

39. Smith, F., Hardman, F. & Higgins, S. (2007). Gender inequality in the primary classroom: Will interactive whiteboards help? *Gender and Education, 19* (4), 455-469.

40. Stake, J. E. (2006). Pedagogy and student change in the women's and gender studies classroom. *Gender and Education, 18* (2), 199–212.

41. Stake, J. E. & Hoffmann, F. L. (2001). Changes in student social attitudes, activism, and personal confidence in higher education: The role of women's studies. *American Educational Research Journal, 38*(2), 411-436.

42. Stanworth, M. (1990). *Gender and schooling: A study of sexual divisions in the classroom*. Cambridge: The University Pres.

43. Streitmatter, J. (1994). *Toward gender equity in the classroom: Everyday teachers' beliefs and practices.* New York: State University.

44. Tan, M. (2007). Eğitimde cinsiyetçilik: Farkında mıyız? *Kadın, 8 Mart, Eğitim-Sen Bülten Eki*, 15-18.

45. Tan, M. (2008). Eğitim. M. Tan, Y. Ecevit, S. S. Üşür ve S. Acuner (Eds.), *Türkiye'de Toplumsal Cinsiyet Eşitliği: Sorunlar, öncelikler ve çözüm önerileri* (ss.23-105). İstanbul: TÜSİAD-KAGİDER.

46. Tiedemann, J. (2002). Teachers' gender stereotypes as determinants of teacher perceptions in elementary school mathematics. *Educational Studies in Mathematics, 50*(1), 49-62.

47. Torun, Y. (2002). *Gender bias in student-teacher interactions and its effect on reproduction of gender roles in the classroom*. Unpublished master's thesis. Department of Gender and Women's Studies, METU.

48. Tsouroufli, M. (2002). Gender and teachers' classroom practice in a secondary school in Greece. *Gender and Education, 14*(2), 135-147.

49. UNDP (2001). *Introductory gender analysis ve gender planning training module for UNDP staff*. Retrieved from http://arabstates.undp.org/contents /file/Gender Mainstreaming Training.pdf

50. UNESCO (2000). *Gender sensitivity, module 5*. France: UNESCO. Retrieved from http://unesdoc.unesco.org/images/0013/001304/130428e.pdf

51. UNESCO (2004). *Gender sensitivity: A training manual for sensitizing education managers, curriculum and material developers and media professionals to gender concerns*. Paris: UNESCO. Retrieved from http://unesdoc.unesco.org/images/0013/001376/137604eo.pdf

52. UNESCO (2010). *Gender sensitizing. Reorienting teacher education to address sustainable development: Guidelines and tools*. Bangkok: UNESCO. Retrieved from http://unesdoc.unesco.org/images/0018/001890/189054e.pdf

53. UNICEF (2003). *Eğitimin toplumsal cinsiyet açısından incelenmesi Türkiye raporu*. Ankara: UNICEF. Retrieved from http://www.unicef.org/turkey/pdf/_ge21.pdf

54. USAID (2007). *Gender terminology*. Retrieved from http://www.usaid.gov

55. Weiner, G. (2000). Gender and teacher education in Europe: A critical review of gender and teacher education in Europe. *Pedagogy, Culture ve Society, 8* (2), 233-247.

56. Younger, M. & Warrington, M. (2008). The gender agenda in primary teacher education in England: Fifteen lost years? *Journal of Education Policy, 23*(4), 429–445.

57. Zittleman, K. & Sadker, D. (2002). Gender bias in teacher education texts: New (and old) lessons. *Journal of Teacher Education, 53* (2), 168-179.

58. Sabancı University, Purple Certificate Program http://genderforum. sabanciuniv. edu/tr/Morserttanitim

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Assesment of Water Quality Parametres oF Drina River (West Serbia) in the Period 2004-2011

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Abstract. A Water Quality Index (WQI) is a numeric expression used to evaluate the quality of water bodies and make it easier understood by managers. This paper aims to assess water quality of Drina River in Serbia for the 2004 – 2011 period. For this purpose authors applied: Serbian Water Quality Index (SWQI). WQI value is dimensionless, single number ranging from 0 to 100 (best quality) derived from numerous physical, chemical, biological and microbiological parameters. For the Drina River SWQI was mainly rated as excellent. This study shows a clear decrease in water quality during summer period. Additionaly, this study shows that water quality along Drina River decreases slightly downstream, but it still provides values that according to SWQI descriptive quality indicator have been defined as excellent (90–100). This methodology includes parameters for assessment of organic loading, but does not involve parameters of heavy metals concentration.

Keywords: SWQI; Drina; River; Serbia; water quality.

Introduction

Rational and preservation utilization of water resources represent one of the main problems of the 21st century. The important aspects taken into consideration when examining the top-priority problems of water quality are the economic influence, the influence on human health, the influence on the ecosystem, the influence of the geographic area as well as the duration of the influence (Dalmacija, 2004).

In order to provide the sustainability of ecological balance, the presence and quality of water are very important (Karadavut et al., 2011) and there have been more researches based upon water

quality observing (Ferenczi & Balog, 2010, Parvulescu & Hamchevici, 2010). Anthropogenic influences can cause negative consequencies in short period of time as far as water quality is concerned (Yunus & Nakagoshi, 2004), whereas waterbody pollution represents the result of human activities on one hand, and intensive urbanization development on the other hand (Dragićević et al., 2010). The organic solid load and the dynamics of its degradation are very good indicators of the anthropogenic impact on the waters (Gurzau et al., 2010).

Water Quality index attempts to provide a mechanism for presenting a cumulatively derived numerical expression defining certain level of water quality (Miller et al, 1986), and is useful for comparative purposes and when general questions are addressed (Hallock, 2002, Bordalo et al, 2006). In this study, the water quality status as well the spatial and temporal trends over eight year period were assessed to four different locations on Drina River.

Material and methods

Sampling Area

Drina River is right and the biggest tributary of Sava River. It is created by merger of Tara and Piva River at Šćepan Polje. Catchment area is 19 570km^2. In Serbia catchment area is 6007km^2 Drina River represents the state border between Republic Serbia and Bosnia and Herzegovina. Average altitude of catchment area is 934 m. Composition of Tara and Piva rivers is at 432 m and the confluence is at 75 m. The length of Drina River is 346 km (Gavrilović, Dukić, 2002).

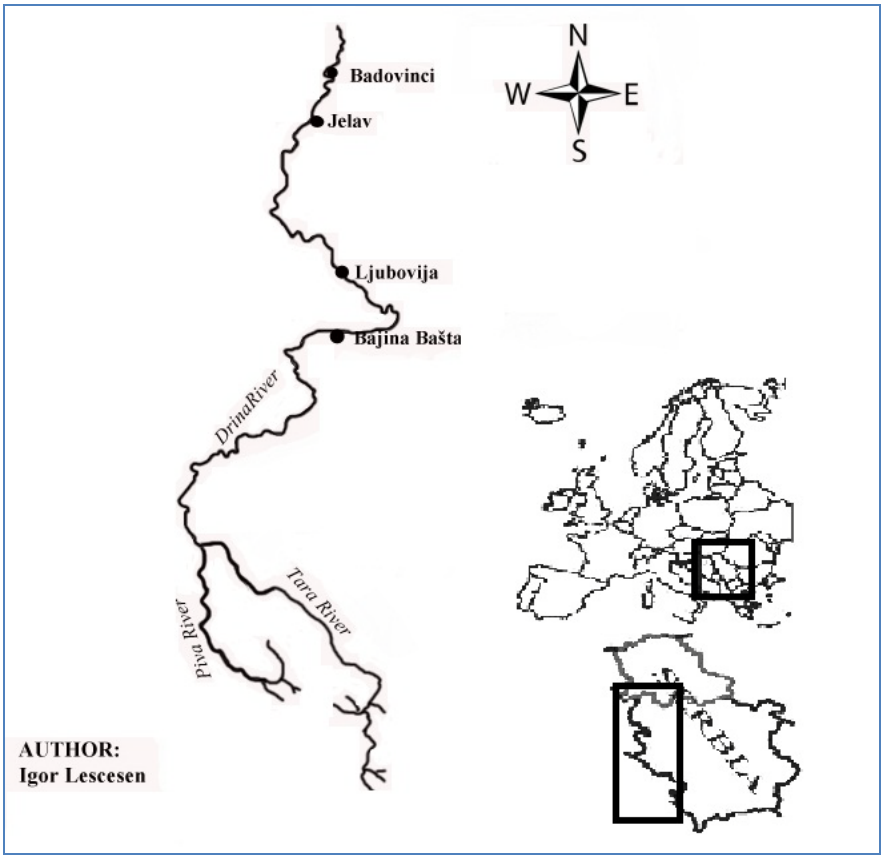


Figure 1: Geographical location of stations used for assessment of SWQI for Drina River (made by: Igor Leščešen)

Data and Methods

Database of Republic Hydrometeorological Service for period 2004-2011 (RHMS, 2009) was used to present the existing state of water quality of Drina river. Waterflows in Serbia are divided in I, IIa, IIb, III and IV classes according to set limit values of quality markers (Official Bulletin of SFRY nb. 6/78).

Parameters of physical, chemical, biological and microbiological water quality were measured at the four stations on Drina river: Bajina Bašta, Ljubovija, Jelav and Badovnici during period 2004-2011. Their values are presented in Hydrological annual book for 2004, 2005, 2006, 2007, 2008, 2009, 2010 and 2011 of Republic Hydrometeorological Service of Serbia. SWQI was calculated for each station and each measuring.

Serbian Water Quality Index (SWQI) was used for description of water quality. This system of surface waterbodies quality description represents the way of quality estimation for certain paramteres group, whereas earlier researches and studies show that this method ensures general overwiev of surface water quality at certain place (Veljković, 2000a; Veljković 2001; Veljković 2003; Đurašković & Vujović, 2004; Veljković, 2007; Đurašković & Tomić, 2009, Pantelić et al., 2012). This method is based upon the fact that ten chosen paramtres (oxygen saturation, BOD, ammonium, Ph value, total oxidised nitrogen, orthophospates, suspended solids, temperature, conductivity and coliform bacteria) with their quality (*qi*) represent features of surface water reducing them at one index number. Influence of each of ten chosen parametres on general water quality is not the same, so that each of them was assigned the wieght (*wi*) and score of points according to their contribution to water quality endangering. The result (*qi*x*wi*) gives the index100, as an ideal summation of weights of all parametres (Oregon Water Quality Index Summary Report, 1996-2005*)*. Index points from 0 to 100 will be assigned to particular waterbody according to the points assigned to particular parametres. Formula used for SWQI calculation is:

SWQI= 0,18%O2 + 0,15BPK5 + 0,12NO4 + 0,09pH + 0,08N + 0,08PO4 + 0,07SM + 0,05t + 0,06µS + 0,12MPN

Descriptive quality indicator have been defined for each SWQI vales ranging from very poor (0–38), poor (39–71), good (72–83), very good (84–89), and excellent (90–100). Main limitation for SWQI is relative small number of parameters. Used parameters provide information about organic loading, but not about heavy metal pollution. Also, SWQI can be calculated even in a case of missing some values. It means that, practically, SWQI can be calculated on the basis of just one parameter.

Results

Since there is no single, universal parameter that adequately describes surface water quality, investigators typically use several indicators related to sanitary quality, ability to sustain aquatic life, ecosystem productivity and aesthetics (Pharino, 2007).

Average eight year values for ten parameters used for SWQI calculations are presented in Table 1, Temperature increased continuously downstream, from 11,9 ^{o}C to 12,5 ^{o}C. The water acidity measures grom 8, till 8,1. Highest average conductivity was recorded on Jelav station 299,2 µS cm-1. Average Oxygen saturation for research period is 102,4%. Biochemical oxygen demand is used as a measure of organic wasteload strength, and on Drina River it varies 0,8 on Ljubovija station till 1,6 on Bajina Bašta station. Another important indicator of water quality is the amount of solids in the water column – both dissolved (filterable) solids and not dissolved (suspended) solids (Pharino, 2007). Suspended solids show progressive increase from Bajina Bašta station (4,7 mg/l) till Badovinci station (14,6 mg/l). Orthophospates show stable stable values on all stations during 2004 - 2011 period, (0,1mg/l). Values of coliform bacteria rise continuously from Bajina Bašta station (1824,8), Ljubovija station (2746,5) till Jelav station, were the highest values have been measured (4771,9). on Badovinci station the value the value of coliform bacteria is second lowest (after Bajina Bašta) and measures 2600 n/l.

Table 1: Averaged values for ten water parameters included for calculation of SWQI for Drina River coverd by this study during 2004 – 2011 period

Station	Temperature (^{o}C)	pH	Conductivity (µS cm^{-1})	Oxygen saturation (%)	BOD_5 (mg/l)	Suspended solids (mg/l)	Total oxidised nitrogen	Orthophospates (mg/l)	Amonium (mg/l)	coliform bacteria (n/l)

							(mg/l)			
Bajina Bašta	11,9	8	285,4	103,1	1,6	4,7	0,5	0,01	0,02	1824,8
Ljubovija	11,7	8,1	287,9	102,5	0,8	7,3	0,5	0,01	0,01	2746,5
Jelav	12,3	8,1	299,2	101,8	0,9	8,3	0,5	0,01	0,05	4771,9
Badovinci	12,5	8,1	297,4	102,3	1	14,6	0,4	0,01	0,02	2600

SWQI was calculated 80 times for eight years for Bajina Bašta station (table 1) and ranged from 92 to 94 (bouth excelent). In the case where the SWQI was lowest (92 and 93) in 2006, 2007, 2008, 2010 and 2011, result should be considered as questionable, because of lack of values for some months (-, in table).

Table 2: Monthly values of SWQI for Bajina Bašta station

Mounth	2004	2005	2006	2007	2008	2009	2010	2011
I	95	95	-	-	-	96	95	-
II	95	97	91	93	93	-	89	92
III	96	93	-	-	93	95	95	-
IV	89	94	94	-	93	-	94	95
V	95	96	94	94	94	95	94	93
VI	93	95	92	95	93	96	94	94
VII	93	94	-	93	92	89	94	91
VIII	93	92	92	90	90	89	85	89
IX	88	92	91	94	94	90	91	92
X	95	93	90	94	91	96	-	91
XI	97	93	93	93	-	94	93	-
XI	97	93	-	-	89	97	94	93
Average	**94**	**94**	**92**	**93**	**92**	**94**	**93**	**92**

SWQI was calculated 89 times for Ljubovija station (Table 3) and ranged on average from 92 to 94 (excelent).

Table 3: Monthly values of SWQI for Ljubovija station

Months	2004	2005	2006	2007	2008	2009	2010	2011
I	93	94	-	94	-	97	95	95
II	95	89	91	94	94	94	95	-
III	95	95	95	-	94	97	95	-
IV	95	93	94	95	93	97	97	97
V	95	90	97	92	94	95	92	97
VI	95	96	97	94	86	94	93	94
VII	90	90	93	90	92	91	92	92
VIII	89	90	94	-	92	89	92	92
IX	90	92	93	94	93	91	94	93
X	95	96	94	93	95	96	92	91

XI	97	97	95	-	88	92	85	93
XII	97	98	95	97	91	94	97	93
Average	**94**	**93**	**94**	**94**	**92**	**94**	**93**	**94**

For Jelav station SWQI was calculated 96 times on monthly basis for eight years. Its values ranged from 91 to 94 (excelent). The monthly results are represented in table 4.

Table 4: Monthly values of SWQI for Jelav station

Month	2004	2005	2006	2007	2008	2009	2010	2011
I	94	95	92	92	91	93	93	93
II	96	95	94	93	93	97	92	95
III	95	90	92	93	92	90	95	94
IV	94	93	85	93	93	95	95	94
V	96	95	97	92	94	95	95	93
VI	97	94	86	87	87	92	94	91
VII	92	91	91	85	90	86	88	91
VIII	91	88	88	90	84	90	89	89
IX	86	93	90	93	94	91	91	89
X	95	94	92	90	93	91	92	90
XI	93	95	98	91	91	95	93	95
XII	94	94	94	94	90	94	94	85
Average	**94**	**93**	**92**	**91**	**91**	**92**	**93**	**92**

Badovinci is the forth station from which date was used for calculating SWQI. It was calculated 95 times and its values ranged from 90 to 93 (excelent). The lovest average year value of SWQI for entire Drina river was measured on this station in 2010, 90.

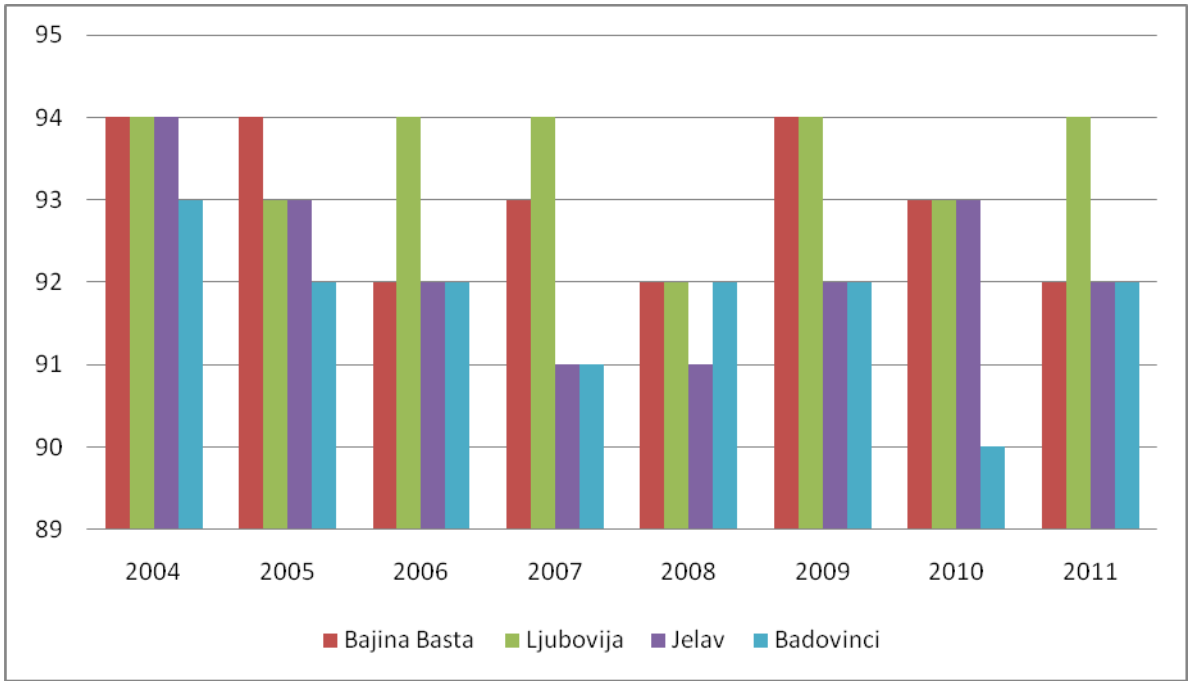
Table 5: Monthly values of SWQI for Badovinci station

Month	2004	2005	2006	2007	2008	2009	2010	2011
I	90	97	-	89	94	91	89	94
II	95	95	93	93	94	95	92	95
III	93	91	93	92	93	95	90	93
IV	93	94	86	86	93	95	91	95
V	95	94	91	93	91	91	97	94
VI	93	92	92	87	85	93	88	90
VII	91	89	91	86	91	91	89	90
VIII	93	86	90	91	88	89	87	90
IX	91	90	92	93	92	91	92	86
X	95	94	93	90	94	93	93	93
XI	95	92	95	97	92	94	84	93
XII	95	92	94	95	91	90	91	93
Average	**93**	**92**	**92**	**91**	**92**	**92**	**90**	**92**

The data which are used for this study are the most complete for the Jelav and Badovinci stations, as for the other two stations, that are more upriver, Bajina Bašta and Ljubovija, there are some missing data on monthly period, specifically, in on Bajina Bašta station in 2006 there is no data for January, March, July and December. For 2007, January, March, April and December,

2008, January and November, 2009, February, April, 2010, October and 2011, January, March and November. For the Ljubovija station in 2006 there is no data for January, 2007, March, August and November, 2008, January, and 2011, February and March.

Figure 2: Average values of SWQI for Drina river per year



Values of SWQI for research period 2004 to 2011 are presented on Figure 1. We can see that the highest values are measured on Ljubovija station. On average for the entire research period value of SWQI for Ljubovija station is 93,5. Average value for Bajina Bašta is 93, Jelav station 92,3 and Badovinci station 91,8. These values indicate that the quality of water in Drina river, according to SWQI can be classified as excellent.

Discussion

The water quality status and the spatial and temporal trends along Drina River were assessed through the application of ten parameter WQI, to a eight year public database of environmental data. In the case of Drina River in should be stated that the index is not adopted to a specific use, such as bathing water or fish spawning, but rather prodced a general index to determine the overall water quality.

According to the SWQI, water quality of Drina River in Serbia during period 2004 - 2011, was assessed excellent. Values of SWQI for research period vary from 90 to 94. Both values are classified according to SWQI descriptive quality indicator have been defined as excellent (90-100). However, these results should be accepted as questionable, because SWQI gives information about organic loading, but not about heavy metals pollution. Along 346 km stretch of the river, the water quality droped modestly but steadily downstream.

Temperature can also have influence on water quality. If water tempereature in river is higher, there is intensive biological activity and dissolved oxygen concentration lessens (Sa´nchez, 2007). Sesonal variance in water quality was observed and some patterns were noticed on all four stations. Lowest values were opserved at all stations during July, August, September and October. On the Bajina Bašta statino, average water quality index for August during 2004 – 2011 period is 89 (very good). Highest values were observed during spring and winter months. Therefore, water quality is worse in warmer period of the year. Numerous researches stated the same trend, Suquia

River, Argentina (Pesce & Wunderlin, 2000), Odzi River, Zimbabwe (Jonnalagadda & Mhere, 2001), Bangpakong River, Thailand (Bordalo et al., 2001), San Vicente Bay, Chile (Rudolf et al., 2002), Pampa Murillo, Mexico (Herna´ndez-Romero et al., 2004), Veliki Bački kanal, Serbia (Pantelić et al, 2012). This study shows a clear decrease in water quality during summer period.

According to statistical data processing we can state that water quality of Drina river at four measuring points allows its exploitation. Season and natural factors such as air temperature, do not have significant influence on Drina river pollution.

In conclusion, this study shows the importance of applying a WQI that reflects the collectiv influence of various criteria and allows easy interpretation of data from monitoring networks. Additionaly, this study shows that water quality along Drina River decreases slightly downstream, but it still provides values that according to SWQI descriptive quality indicator have been defined as excellent (90–100). Based on the results of the study that analysed the impact of ten parameters measured on four stations during 2004-2001 period on water quality of the Drina River it has been established that natural factors, primarily water temperature affect changes in water quality throughout the years. Although the anthropogenic impact on the quality of river is far more intensive, this study has established that natural factors may affect the increase or reduction of Water Quality Index throughout the investigated period up to a certain extent.

References:

1. Bordalo A. A., Teixeira, R., William, J. W., (2006): *A Water Quality Index Applied to an International Shared River Basin: The case study of the Duro River*. Environ Manage 38:910-920.

2. Bordalo, A. A., Nilsumranchi, W. & Chalermwat, K., (2001): *Water quality and uses of the Bangpakong River (Eastern Thailand)*. Water Research, 35, 3535–3642.

3. Dalmacija, B. & Tumbas-Ivančev I., (2004): *Water analysis - quality control, results interpretation*. Faculty of Sciences, Department of Chemistry, Novi Sad. [In Serbian]

4. Dragićević, S., Nenadović S., Jovanović B., Milanović M., Novković I., Pavić D. & Lješević M., (2010): *Degradation of Topciderska river water quality (Belgrade)*. Carpathian Journal of Earth and Environmental Sciences, 5, 2, 177-184.

5. Đurašković, P. N. & Tomić, N. (2009): *Skadar Lake Water Quality by WQI Method*. Conference ``Zastita voda 09``, Zlatibor, Serbia. [In Serbian]

6. Ferenczi, L. & Balog, A. (2010): *A pesticide survey in soil, water and foodstuffs from central Romania*. Carpathian Journal of Earth and Environmental Sciences, 5, 1, 111 – 118.

7. Gavrilović, Lj., Dukić, D. (2002): *Rivers of Serbia*, Institute for Textbooks, Belgrade, [In Serbian]

8. Gurzau, A.E., Popovici, E., Pintea, A., Popa, O., Pop, C. & Dumitrascu I. (2010): *Quality of surface water sources from a central transylvanian area as a possible problem for human security and public health*. Carpathian Journal of Earth and Environmental Sciences, 5, 2, 119 – 126.

9. Hallock, O. (2002): A water quality index for ecology´s stream monitoring program. Washington State Department of Ecology, Olympia WA. Publication No 0203052, 23 p.

10. Herna´ndez-Romero, A. H., Tovilla-Herna´ndez, C., Malo, E. A. & Bello-Mendoza, R., (2004): *Water quality and presence of pesticides in a tropical coastal wetland in southern Mexico*. Marine Pollution Bulletin, 48, 1130–1141.

11. Jonnalagadda, S. B. & Mhere G. (2001): *Water quality of the Odzi River in the Eastern highlands of Zimbabwe*. Water Research, 35, 2371-2376.

12. Karadavut, I.S., Saydam A. C., Kalipci E., Karadavut S. & Özdemir C. (2011): *A research for water pollution of Melendiz stream in terms of sustainability of ecological balance*. Carpathian Journal of Earth and Environmental Sciences, 6, 1, 65-80.

13. Miller, W. W., Joung H. M. & Mahannah C. N. (1986): *Identification of water quality differences in Nevada through index application*. Journal of Environmental Quality, 15, 265-272.

14. Oregon Water Quality Index Summary Report, Water Years 1996-2005, Curtis Cude, DEQ Laboratory Division, Water Quality Monitoring Section, USA.

15. Pantelić, M., Dolinaj, D., Savić, S., Stojanović, V., Nađ, I. (2012): *Statistical Analysis of water quality parameters of Veliki Bački Canal (Vojvodina, Serbia) in period 2000-2009*. Carpathian Journal of Earth and Environmental Sciences 7 (2), 255-264.

16. Pârvulescu, L. & Hamchevici, C. (2010): *The relation between water quality and the distribution of Gammarus balcanicus schäferna 1922 (amphipoda: gammaridae) in the anina mountains.* Carpathian Journal of Earth and Environmental Sciences, 5, 2, 161–168.

17. Pesce, S. F. & Wunderlin, D. A. (2000): *Use of water quality indices to verify the impact of Cordoba City (Argentina) on Suquia River*. Water Research, 34, 2915–2926.

18. Pharinp, C. (2007). *Sustainable Water Quality Management Policy*, Published by Springer, P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

19. Rudolf, A., Ahumada, R. & Pe´rez, C. (2002): *Dissolved oxygen content as an index of water quality in San Vicente Bay, Chile (36 degrees, 450S).* Environmental Monitoring and Assessment, 78, 89–100.

20. Veljković, N. (2000a): *Determinig water quality index of the Southern Morava basin by the application of WQI method.* Waters Protection 2000, Yugoslav Society for Waters Protection, Belgrade. [In Serbian]

21. Veljković, N. (2001): *Measuring indicators of sustainable water development for agglomerations in theSouthMorava basin.* 11th Stockholm Water Symposium, Abstract Volume: Building Bridges Through Dialogue, Stockholm, Sweden.

22. Yunus, A. J. M. & Nakagoshi N. (2004): *Effects of seasonality on streamflow and water quality of the pinang river in Penang Island, Malaysia*. Chinese Geographical Science, 14, 2, 153-16.