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Automat. Comput. Appl. Math.
Volume 20 (2011), Number 3

AUTOMATION

Modeling and robust control of pH neutralisation process

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Abstract— **This paper focuses on the modeling, simulation and control of a nonlinear pH neutralization process. The developed model uses the material balance chemical equations, and it is tested with data gathered from an industrial process. The control strategy presented here consists of a robust controller that uses the simplified linearized model of the process. The controller ensures good response and stability despite all uncertainties the model presents.**

Keywords- process control; robust control; simulation; chemical reactors; matematical modeling; pH neutralisation;

I. INTRODUCTION

The pH determines if a substance possesses acid or alkaline proprieties. Basically it determines the number of hydrogen ions, or better said, the activity of hydrogen ions in the tested solution.

The process is seen as being of great importance in a large part of the industrial processes like those in chemical industries, bioprocess and environmental industries.

Controlling the pH process usually raises difficulties, being described by researchers in the past as the most difficult single loop to control. It has this reputation due to the high nonlinearities and also due to the time variation and to the complexity characteristic of the most process streams. This non-linearity is represented by the "S" shape in the titration curve and is seen as a variation of the process gain in the reactor.

Over the past years efforts were made to solve the problem of modeling and controlling this nonlinear process. As a result, different control strategies and modeling solutions were developed, each having a different degree of sophistication.

McMillan in 1984 developed a pH control, concentrated on linear controllers which also uses feed-forward and cascade strategies. A drawback of this linear control is that it is not robust and if disturbances are large the performance is reduced. As a result other nonlinear controllers were developed in order to satisfy the tight conditions of this nonlinear process.

Gustafsson and Waller (1983) were the first to introduce the concept of reaction invariant in order to overcome the time-varying and nonlinearities of the process and designed an adaptive pH control system that had the total ion concentrations of weak acids as adjustable parameters. Gustafsson (1985) presented the experimental results of the adaptive nonlinear pH controller using this reaction invariant concept. In year 1992, they illustrated the advantages and drawbacks of linear and nonlinear continuous control of the pH neutralization processes through simulations and laboratory experiments.

After studying their work one can say that the nonlinear adaptive control strategy is suitable for obtaining good results in overcoming the time-varying properties and the nonlinearities of the pH neutralization process.

In 1990 Williams developed a two-parameter model that consists of the total ion concentration and dissociation constant of a single weak acid and also designed a regulator to control the multicomponent pH system where the autor estimated two parameters by injecting a strong base at two points of in-line neutralization process. However, the method cannot be applied to the usual pH process, composed of a single pH sensor and a single continuous-stirred tank-reactor (CSTR). The model can approximate in a satisfying manner the operating region of the pH process. Only the operating region is important to the controller so the two-parameter model, can produce almost the same control performance as the full-order model.

K.K. Biasizzo, I. Skrjanc and D. Matko in „Fuzzy Predictive Control of Highly Nonlinear pH process" proposed a predictive control based on fuzzy model, all the advantages of both fuzzy modeling of a nonlinear processes and DMC control are being accomplished.

This paper is structured in 4 parts. After the introduction, the second part describes the pH neutralization process and also details the actual modeling, and simplified linear model used for control. The third part presents the developed robust controller design. The simulation results are also presented in this third section of the paper. The conclusions will represent the last chapter of the paper.

II. PH PROCESS MODELING

The work in this paper is validated using an industrial scale nonlinear titration process. This is the test example and it helps in examining the modeling and validation process of chemical neutralization.

This paper focuses on the titration reaction between acid solution and an alkaline one. These solutions will make up the process and the titrating streams. Solutions can be chosen to be either strong or weak species.

The chemical dissociation of the weak acids and bases involved in the final product specify the number of hydrogen ions. All weak solutions have the ability to resist changes in pH. This ability it is called buffering. For example, a weak acid will not be dissociated completely, so it will be able to absorb hydrogen ions and convert them into undissociated

Determination of the Parasite Heat Received by a Cryogenic Distillation Column during an Isotope Separation Process

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***Abstract*—Isotope separation by distillation was successfully applied in the case of light elements like boron, carbon, nitrogen, or oxygen due to the relatively large mass difference between the isotopes of the same element. Usually, the raw material used in the isotope separation by distillation consists in gaseous mixtures and thus, cryogenic distillation is used. Because plant parameters like vapor molar flow rate, relative volatility, or separation depend on temperature, an accurate estimation of the heat received by the distillation column during the separation process is compulsory. Since the separation process occurs at very low temperature, the parasite heat must be known as accurate as possible for future tasks in modeling, simulation, and process control. In this paper we present an estimation method of the parasite heat received by the distillation column which is thermally insulated by a multilayered vacuum jacket during an isotope separation process.**

Keywords-isotope separation; cryogenic distillation; parasite heat; multilayered vacuum jacket

I. INTRODUCTION

Isotopes of various elements have applications in different fields such as medicine, hydrology, or geology. Some of these applications make use of techniques like determining the isotopic signature of a certain material, or, in some cases, the use of isotopic labeled compounds in order to trace them in a system [1]-[3]. Particularly, the interest for ^{13}C isotope has increased lately due to its applications in medicine, organic chemistry, and various biological experiments.

Some practical methods of isotope separation are chemical exchange processes, diffusion-based separation, laser separation, chromatography methods, and distillation. Due to the relatively large mass difference between the isotopes of the light elements, isotope separation by distillation has been proved to be an effective method in the case of separation of isotopes of elements like boron, carbon, nitrogen, or oxygen [4]-[6].

Particularly, in the case of separation of carbon isotopes, it has been shown that the isotope effect based on the vapor pressure difference is the highest in the case of carbon monoxide (CO) and methane (CH_4) [7], [8]. Therefore, these substances are often preferred as raw material in ^{13}C distillation-based separation.

The experimental pilot-scale plant that was developed at the National Institute for Research and Development of Isotopic and Molecular Technologies in Cluj-Napoca, Romania is shown in Fig. 1. The pilot-scale plant separates the stable isotopes of carbon (i.e. ^{12}C and ^{13}C) by cryogenic distillation of the carbon monoxide. The distillation column is configurable in several ways. One configuration consists in a cascade of two columns, a primary column and a final column. The primary column has 2500 mm in height and an inner diameter of 26 mm, while the final column has 4500 mm in height and an inner diameter of 16 mm. The primary column is packed with Heli-Pak stainless steel wire of 2 mm×2 mm×0.2 mm while the final column is packed with Heli-Pak stainless steel wire of 1.8 mm×1.8 mm×0.2 mm. Another configuration consists in a single column of 7000 mm in height and an inner diameter of 16 mm packed with Heli-Pak stainless steel wire of 1.8 mm×1.8 mm×0.2 mm [9].

The column is fed up with highly purified carbon monoxide, and the extracted waste gas (i.e. ^{12}CO enriched) is withdrawn from the top of the column, while ^{13}C enriched product is taken out from the base of the column. The internal vapor stream is ensured by a variable heating resistance, while the total condenser provides the reflux.

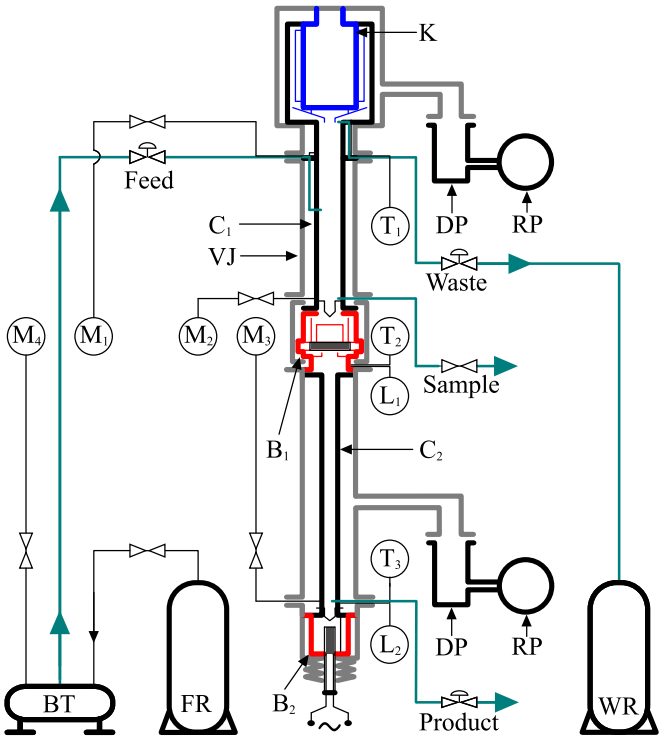

Figure 1. Experimental pilot-scale cryogenic distillation plant with condenser K, primary column C_1, final column C_2, reboilers B_1-B_2, vacuum jacket VJ, rough pump RP, diffusion pump DP, temperature sensors T_1-T_3, manometers M_1-M_4, level sensors L_1-L_2, feed reservoir FR, buffer tank BT, waste reservoir WR.

Flexible rezistive sensor modelling suitable for human movement assesment-Initial results

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Abstract— *In this article the authors present a flexible resistive sensor for human joint bending assessment. The sensor is dynamically and statically modeled, with the static model sufficiently simple and reliable during the measurement of a wide range of bending angles. The modeled sensor presents good behavior especially under medium bending angles and low angular acceleration and velocities. As the first tests show a flexible resistive sensor based human assessment system can be accomplished considering the provided sensor model but further tests must be carried out.*

Keywords-sensor modelling; flexible resistive sensor; One-Directional Flex Sensors;

I. INTRODUCTION

In the last decades the necessity of human movement monitoring and assessment has raised due to the increase of the quality of life, the ageing population and the request for advanced recovery processes enhanced by modern technologies. As underlined by scientists, the recovery process is accelerated when feedback is provided to the patient, especially at the beginning of the recovery process. The most used evaluation techniques are the image based ones, which generally require a closed environment, several cameras and active or passive markers placed on the investigated object. The biggest drawbacks of these systems are the cost and the environmental constrains, which generally restrict the movements to a narrow space. Another very important facet of these evaluation techniques is the registration of sport performances and human movement monitoring in their natural environment. Regardless the aim of the measurement, for recovery purposes or data acquisition for statistical or biomechanical processing, they generally ask for outdoor measurements.

Another category of monitoring devices consists of inertial motion units (IMU). An IMU incorporates several accelerometers and gyroscopes, depending on the complexity of the evaluated system. The accelerometers measure the displacement of a proof mass with respect to the accelerometer casing, while the gyroscopes are based on the principle of angular momentum conservation [1]. The accelerometers and IMU are used in several different applications as showed in [2] beside many new implementations like digital pen for handwriting [3] or human body motion detection [4] etc. Its main weakness, beside the data filtering, is the relatively height cost and low flexibility which limits their use in certain applications.

In order to satisfy these requirements flexible resistive, capacitive or inductive sensors are used. These flexible sensors can be mounted on different joints to evaluate the human body kinematics even if the center of rotation is variable. In [5] a resistive sensor based data glove is presented as 3D human machine interface where several sensors are placed upon the interphalangeal and metacarpo phalangeal joints. A more complex system is considered to be the human trunk, first of all due to its numerous elements and articulations, beside the amplitude of movements in respect to vertebral dimensions. To measure accurately the spinal movements at vertebral level, video fluoroscopy or marker attachment to vertebral process via surgical procedure is required. A simple but less accurate method consist of a sensorized cloth where inductive sensors are positioned strategically at abdominal and worthy regions [6]. Usually non-invasive methods are preferred despite the lower performances and precision.

The most common commercially available, low cost, bending sensors are the resistive ones. They can be found in different sizes, from several manufacturers and are easy to use for joint bend measurements even if the center of rotation moves along a path. The sensor's length is selected according to the human joint characteristics. Based on the electrical parameters (specifications) data acquisition board is designed.

Manufacturers of commercially available flexible resistive sensors generally don't provide rigorous description of the commercialized sensors in term of materials or characteristic functions. On the other hand the existing piezoresistive effect models cannot describe the functionality of these sensors due to their constructional improvements like metallic pattern deposited on the sensor surface for resistivity reduction on some portions or uneven cross section of the sensitive layer for linearity etc. In order to use these sensors in different applications a model and a characteristic function must be defined. To fulfill these gaps the authors developed a test stand where a commercially available flexible sensor is tested for angular displacement measurement.

The paper is structured in five parts. After a short introduction the resistive sensor operation principle and its physical construction is presented. In part three the experimental stand is described, while the following part consists of the sensor modeling. The first model concerns the evaluation of the system dynamical behavior modeled with a second order circuit, afterward the static model is presented. The last paragraph concludes the authors work and gives the direction of future works.

Signal Recovery from the Time Evolution Graph using Image Processing Techniques

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***Abstract*—The paper presents a practical method for signal recovery from the graphical representation of its time evolution, using image processing techniques. For the parametric identification of a hydraulic positioning system of an unloading billets machine the authors have access only to the graphs representing the time evolution of the system's input and output signals. These graphs are provided by the unloading process monitoring system in form of images. In order to identify the model from the experimental data, or to validate the obtained mathematical model, one needs to know the values of the input and the output sampled signals, on which the graphs were initially constructed. For restoring the sampled-data signals from the input and output positioning system charts, image processing techniques were used and a signal recovery algorithm is described. The assessment of the results is made using MATLAB software.**

Keywords- signal recovery; image processing; time evolution graph; sampled-data signals; hydraulic positioning system;

I. INTRODUCTION

The main method for obtaining seamless tube pipes is the process of hot rolling [1]. This process is composed of several stages, each with a base aggregate and its ancillary equipments. The connection between the rotary hearth furnace (RHF) and the drilling mill, the first and the second important aggregates of the hot rolling process, is made by the RHF's unloading machine [2, 3]. This unloading machine is designed to remove the heated billets from the furnace and place them on a roller conveyor. In addition to the unloading machine the RHF is equipped with a loading machine. The main equipments of the RHF are presented in figure 1.

The unloading machine from a company that produces seamless tube pipes through the hot rolling process basically works as a trolley running on rails, for front and back movements [4]. For a proper handling of billets, the unloading machine is provided with a long arm of about six meters. The arm has a clamp at the furnace end (see figure 2). The clamp has one fixed and one movable jaw, and the jaws opening is 235 millimeters (see figure 3).

At the outlet door of the furnace the unloading billets have a small displacement from the rail way axis (see figure 4). This is due to the billet motion relative to the furnace hearth, during the rotation process, or due to small hollows that occur at the surface of the hearth. Because of the unloading billets displacement, the unloading clamp needs to be positioned directly over a billet, meaning that the arm has to perform a horizontal positioning movement [5],[6]. The center position of the arm coincides with the roller way axis.

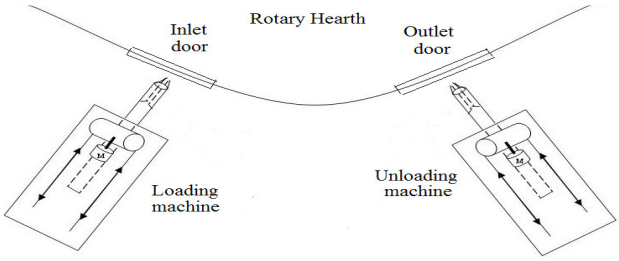

Figure 1. Schematic representation of the rotary hearth furnace equipment

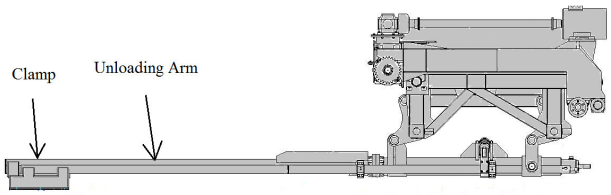

Figure 3. Side view of the unloading machine

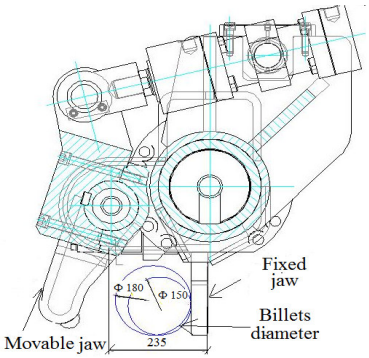

Figure 2. Side view of the unloading clamp

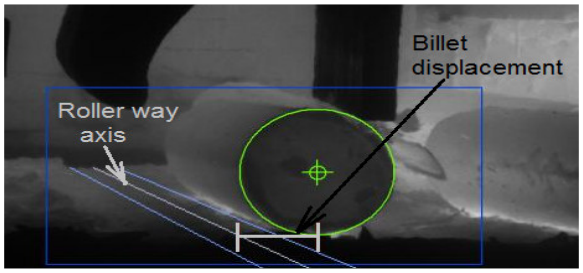

Figure 1. View of billet displacement from the roller way axis

Multivariable Smith Predictor Controller for ^{13}C Isotope Separation Column

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***Abstract*— The (^{13}C) isotope separation column is a complex process with many inputs and outputs, having a strong coupling and large time delays. The main goal of this paper is to design and compare different control strategies: internal model controller (IMC), classical controller using frequency domain design method and a PID controller in a multivariable Smith Predictor structure. This predictor structure is used to compensate the dead time in order to achieve setpoint tracking and disturbances rejection. The control strategy which proves the best performances will be used to be implemented on a process computer to control the ^{13}C isotope separation column.**

Keywords-^{13}C isotope separation column; Smith Predictor; internal model controller (IMC); classical control; multivariable (PID) controller.

I. INTRODUCTION

Multiple-input-multiple-output (MIMO) systems with multiple large time delays and coupling are specific in process industries, especial in chemical industries. Based on the number of input and output variables, the MIMO systems are classified into square and non-square systems. The processes which have the equal number of inputs and outputs are called square systems, while those with unequal number of inputs and outputs define the non-square systems [1].

In the literature according with Smith [2], Ogunnaike and Ray [3], the principal difficulty relating to time delays in feedback control loops often is a serious obstacle to achieve acceptable process operation. The problem is more difficult in case of multivariable systems due to different time delays present in control loops and due to the interactions between the sub-systems [4].

The most important element of the MIMO Smith Predictors is the decoupling of the process. For example, Wang, Zou and Zhang [5], proposed a technique to design the decoupling matrix of the system using a frequency domain approach. Later the IMC method has been used for the same decoupling matrix [6, 7].

The main objective of this paper is to design three control strategies in Smith Predictor structure: IMC approach, multivariable PID and classical control. Based on the results obtained from this paper, the following applications will use the control strategy which provides the best performances, for example to implement on process computer in order to control the ^{13}C isotope separation column.

The paper is organized as follows: Section 2 presents the operation principle of the ^{13}C isotope separation column. Section 3 describes the multivariable mathematical model of the isotope separation process. Section 4 deals with the comparison of three control strategies: IMC, multivariable PID and a classical controller design using frequency domain (FD) synthesis in a multivariable Smith predictor structure. The paper ends with concluding remarks and possible extensions and direction for future research.

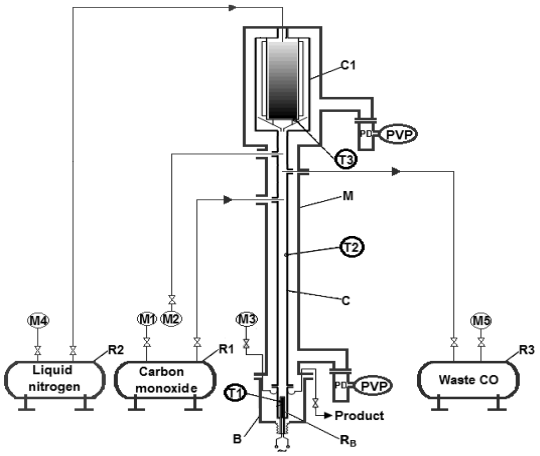

Figure 1. Simplified scheme of the ^{13}C isotope separation column.

II. OPERATION PRINCIPLE OF THE ^{13}C ISOTOPE SEPARATION COLUMN

The process under study is the ^{13}C isotope cryogenic separation column pilot plant built at the National Institute for Research and Development of Isotope and Molecular Technologies Cluj Napoca (N.I.R.D.I.M.T.).

The simplified scheme of the ^{13}C isotope separation column is presented in figure 1. The main components are: condenser (C1) at the top of the column cooled with liquid nitrogen from the tank (R2), which boils at the atmospheric pressure, the distillation column (C) and the boiler (B) at the base of the column. The column (C) is placed in a vacuum jacked used for thermal isolation, since the separation process operates at very low temperatures [8].

The thermal isolation is ensured by special turbo-molecular vacuum pumps (symbolized PVP in figure 1). In case of the ^{13}C isotope separation column, the vacuum level reaches up to a value of $1.33 \cdot 10^{-3}$-$1.33 \cdot 10^{-4}$ (Pa). Manometers (M1, M2, M3, M4 and M5) are installed at several points of the distillation column to measure the pressure [9].

Robust Power Control of a Series Resonant Load Induction Heating Inverters

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***Abstract*—Throughout the heating cycle of an induction heating furnace, parameter variations can be observed, which makes difficult controller design. This paper presents the design and benefits of advanced (robust) controller in comparison with PI controllers tuned using Ziegler Nichols open loop method. For controller order reduction purposes and design simplifications, distinctions will be made between robust controllers designed using two and three uncertainties, demonstrating each approach's performances. Since the robust controllers tuning is difficult, and not in all cases interdependency between weighting functions and performances can be found, genetic algorithms will be used. Step responses will be shown for H_2, H_∞ and PI controllers, illustrating each designs performances.**

Keywords-induction heating; robust control

I. INTRODUCTION

Electromagnetic induction, the main principle of induction heating was invented by M. Faraday in 1831. This discovery led the design of transformers, motors, generators, etc. First the heat loss was considered a side effect, which engineers tried to minimize. At the beginning of the 20th century engineers and scientists started the research in this field to harness the heat generating properties of the discovered phenomena [1].

In 1927 Electric Furnace Company installed in Sheffield (England) the first induction heating furnace. The positive impact together with the advances in power electronics led the development of modern induction heating inverters with higher efficiency [2].

The block diagram of the studied induction heating inverter is presented in figure 1.

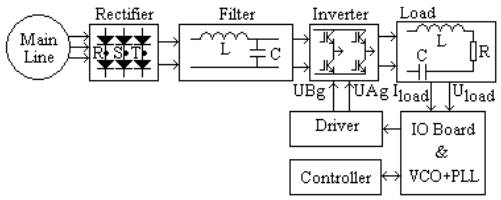

Figure 1. Inverter block diagram.

The system is supplied by the three phase industrial line. The alternating current is rectified using six diodes and supplied to the LC filter. The resulted DC voltage is then supplied to the inverter bridge.

The inverter bridge is constructed of 4 power IGBTs mounted in a H bridge formation. They receive their driving signals from the controller and a PLL circuit. The PLL circuit is necessary to ensure all the time a switching frequency close to the resonant frequency of the load, which is made of an inductor and capacitor. For load matching purposes a matching transformer was added, with a transformation ratio of 12:1.

The power regulation will be accomplished by the studied controllers, through square wave duty cycle variation. An increase of duty cycle has as result an increase of output power, while a decrease of duty cycle, an output power reduction.

To enable controller access to the output power, an interface is required. These are composed of two transformers (voltage and current transformers), RMS-DC converters and operational amplifiers with the necessary circuits.

Through the current transformer the load current is measured while with the voltage transformer the delivered voltage to the load. If these values are converter through RMS-DC converters, a simple multiplication of both has as result the active power delivered to the load. The multiplication of these variables is performed inside the microcontroller through multiplication of the read two analog inputs. The final components listed above are the operational amplifiers. They are used to attenuate and offset the DC voltages resulted from the converters in order to enable use of microcontrollers for power regulation.

A block diagram of the power regulation scheme including the load's circuit can be observed in figure 2.

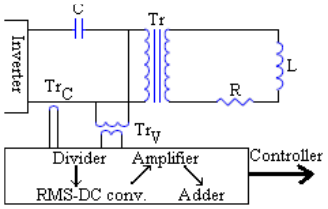

Figure 2. Load with data converters

II. THEORETICAL BACKGROUND OF THE APPLIED CONTROL METHODS

A. H_∞ and H_2 control

Robust controllers were developed specially for the air force. In this demanding domain controllers have to stabilize the systems with uncertainties and ensure acceptable performances. The most significant works were developed by Doyle, Glover, Stain and Francis in the 1980s [3].

Stability Analysis of the Induction Railway Traction Machine in Regenerative Braking

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Abstract — **The advantages of the ac railway traction vehicles using induction traction machines (economical, reliable, reduced maintenance cost) justify the research in regenerative braking. Taking this into consideration, the stability problem of the traction system and of the electrical rail vehicle during regenerative braking is studied. A control strategy is proposed to counteract the effects of the main disturbances in the braking process.**

Keywords: induction motor, regenerative braking, ac Electrical Locomotives

I. INTRODUCTION

The regenerative breaking by railway electric locomotives offers a solution with some real advantages: possibility of the energy saving, the decrease of the maintenance costs on account of the reduction of the mechanical braking system and the rising of the passenger comfort due to the good and smooth transient response of the braking control system.

In the ac traction system (27kV, 50Hz), the standard modern locomotive equipment consists of the step-down main transformer with more secondary windings, the four-quadrant line-side ac/dc converter, the dc link (usually capacitive) circuit and more dc/ac three-phase inverters, one for each induction traction motor. In the motor mode of operation of the traction machine, the energy is transferred from the national grid through the traction power substations and through the overhead catenary system to the electric (traction) equipment of the locomotive, and, finally to the traction motors. By regenerative braking, the induction machine operate as generators with a substantial change of the phase displacement voltage – current for each machine phase. The motor-side converters control the braking torque or the equivalent braking force – with proper values of the stator frequency (ω_S) and stator voltage (U_S) applied to the motor windings. Due to the specific phase angle between the stator current (I_S) and stator voltage (U_S), now the dc-link voltage rises. Under these circumstances, in order to keep the dc-link voltage at a desired level, the line-side converter operates as high-quality on-phase inverter with unity power factor [1]. The step-down main transformer transfers the electric power back to the overhead wire.

In the case of the railway traction system, the power level is very high so that the electrical energy accumulation is not technically possible. The regenerative braking is possible only if equipment able to sink the recovered energy exists. The literature [2] mentions some solutions like:

a. Transfer to other locomotives in simultaneous motoring operation;
b. Transfer to the national grid; in this case the traction power substations are fitted with dedicated equipment;
c. Activation of the on-board equipment (air conditioners, compressors, etc.). Unfortunately, this component has a reduced importance in sinking the recovered energy.

II. THE MAIN DISTURBANCES OF THE REGENERATIVE BRAKING SYSTEM

The operation of the regenerative braking system is strongly conditioned by the possibility to transfer the electrical energy generated by braking. Any disturbance of this power transfer is reflected in the braking torque (braking force), the whole electronic equipment of the electric locomotive being also affected.

The main disturbances which may appear in the braking process may be:

- The absence of any other "close" locomotive in the motor mode of operation;
- The changes of the line voltage delivered by the traction power substation;
- Passage over the neutral zone, by transfer from one section to the next.

In accord to the specific nature of the disturbances, some of them may be approximated by steps while others are modeled by ramps.

III. EQUIVALENT SCHEME OF THE POWER ELECTRIC SYSTEM

The simplified electric scheme is presented in Fig 1.

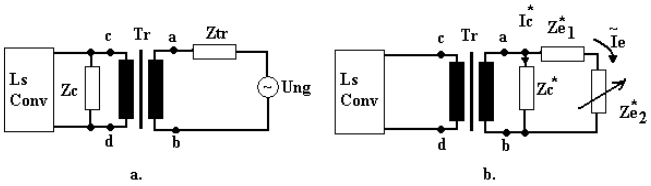

Figure 1. Electric scheme of the power electric system

where:

- U_{ng} is the voltage delivered by the national grid system through the traction power substation;
- Z_N is the considered impedance of the transmission lines;
- U_N is the primary voltage of the main transformer;

Discrete Event Controllers Synthesis Using Genetic Programming

Applied to a Lake System Control

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Abstract—**A novel method for automatic generation of controllers for a certain type of plants is presented in this paper. The plants may be natural discrete event systems, modeled as delay time Petri nets or continuous systems which can be regarded as discrete event systems due to the nature of sensors and actuators. The controllers are generated using the genetic programming algorithm as Lisp expressions and can later be transformed into other forms of representation: time Petri nets or matrix form. The reproduction, mutation and crossover operators are defined for Lisp expressions. The control units consist of a set of transitions joined together using a set of operands. Each transition has an enabling condition from the plant (feedback) and an effect on the plant (control). Automatic generation of controllers for a lake system is presented as a case study.**

Keywords-genetic programming; discrete event systems; time petri nets; delay time petri nets; lake system control; Lis – S expression;

I. INTRODUCTION

Many control applications involve complex systems which cannot be correctly characterized by equations that describe continuous behavior (transfer functions, state space or difference equations, etc.). Such systems usually exhibit discrete (discontinuous) behavior, either by nature, or as viewed from outside. Natural discontinuous systems include for example, discrete processes that take place within the system to be controlled, as it is the case of a manufacturing line for example [16]. Nevertheless, many systems appear to the viewer as black boxes, containing unknown or very complex internal behavior. All that can be seen are the output measurements taken from the sensors and transducers. In some cases, the sensors provide as output a measurement within some given range, which can then be used as it is or converted into digital information. In other cases, the sensor yields a single boolean value. Such sensors include threshold sensors, on/off sensors or even multiple threshold sensors that output several bits. The advantages include low cost, ease of installation and exploitation, robustness, etc.

What is more, many times the control option for some applications involves only on/off or at most multi-positional controllers because of simplicity or low cost of the required equipment, compared to continuous control. A typical and fairly simple application that fits the above description is the on/off temperature control of a heated chamber.

The systems that fit the above plant description can be easily regarded as discrete event systems (DES) and can be modeled and controlled accordingly. While the heated chamber system is a fairly simple example, many other not so simple applications can be imagined, as it is the case of a lake system used for electrical power generation. Hence, the need to study this category of systems emerges. In the following we consider the category of plants that can be modeled as DES.

This type of plants are usually controlled using discrete event controllers which can manage the discrete behavior of the plant. The main control requirements of such plants include, reaching or avoiding a certain set of states. For natural discrete systems however, the control requirements also include deadlock avoidance, executing some cyclic sequences of events with the shortest possible period or avoiding execution of certain sequences of events, etc.

The architecture of the plant and controller system is presented in detail in [17] and reproduced in Fig. 1. The feedback from the plant is represented by the set of measurements r_i and the control actions used to guide the behavior of the plant is c_i. The plant may be modeled as a delay time Petri net (DTPN) (as proposed by Juan et al in [12] and extended by Wang et al. in [13]) or simply as a simulator, as explained in chapter IV. The controller makes use of the set P_C of output places to control the execution of certain transitions from the plant, represented by the set T_C. Similarly, the plant provides feedback to the controller by means of the set of places P_R which control the enabling of certain transitions within the controller, represented by the set T_R.

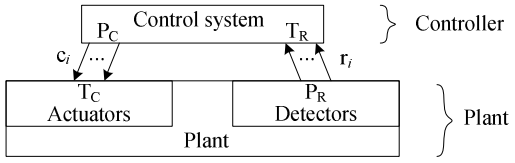

Figure 1. The plant and controller layout

The controller must enable or delay the execution of certain transitions from T_C, based on the information gathered from the states of the feedback set of places P_R. The behavior of the plant is thus controlled in order to match some desired behavior, according to the set of specifications. The problem is to find that particular time Petri net that implements the control system so that the specifications are fulfilled.

The outline of this paper is as follows: first, some related works are identified and analyzed. The equivalent forms for

Techniques and Algorithms for Indoor Localization of a Mobile Terminal

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Abstract—**For several years, the indoor positioning play an important role in literature. In order to develop a system which can be used for locating mobile devices accurately, different techniques and algorithms can be used. Nowadays, a lot of positioning solutions were developed and it is very hard to evaluate and compare them in the same environment in terms of accuracy. Hence, using the OWLPS (Open Wireless Positioning System), this can be possible.**

This paper presents some existing positioning techniques as triangulation, scene analysis and proximity techniques and several of the mobile localization algorithms implemented on OWLPS system. Finally, an experiment using OWLPS are presented.

Keywords- fingerprinting; indoor environments; location; positioning algorithm; signal strength; wireless sensors;

I. INTRODUCTION

In the last years, the positioning-based applications reached an important role. Thus applications used in indoor environments won growing interest. Nowadays, an indoor positioning system is proposed for locating different objects or people in indoor environments by using wireless. This kind of positioning system is very popular since it has many advantages. It does not need any additional infrastructure, the implementation costs are low and a lot of mobile devices have built-in support for wireless. Recently, these systems began to be investigated more often. Nevertheless, on the market there are only several commercial systems. This is because the current solutions do not follow the International standard ISO/IEC 24730 on real time [1].

In order to determine the location of people or objects, one or more technologies are used within the same positioning system. Each technology has different accuracies and reliabilities.

In [2], a wireless client localization system is presented. The system is based on Bayesian hierarchical model. Compared to the previous solutions, this system introduces the notion of a "*fully adaptive zero profiling approach to location estimation*" (it does not train the data).

Another indoor positioning system is ZONITH [3]. This system can be used for locating and tracking people and also assets in indoor environments. For localization, Bluetooth is used. Thus, a person who carries a Bluetooth unit (for example radios, mobile phones, head sets and tags) can be detected by the system.

A system which uses a mixture between ultrasonic and radio frequency is described in [4]. The position in a room is found by using a single RF transmitter and four ceiling mounted ultrasonic transmitters. The system contains only available components being very simple to be installed. Compared to an outdoor GPS (*Global Positioning System*) system, the proposed solution had significant results.

Therefore, different solutions for indoor localization exist. A paper which illustrates analytical models for designing and developing positioning system is [5]. It is based on the Euclidian distance between the localization fingerprint on an area and a signal vector. All the Access Points (APs) visible in a certain area are discovered using this algorithm.

A recent research in this field was made in [6]. The system is used also for indoor localization. The advantage of the system is that the computation complexity is minimized due to the fact that no conventional algorithm is required.

A system which is based on Zigbee is implemented in [7]. The position is found by measuring the received signal strength indicator and after that calculating the approximate distance between the sensors. By testing this solution, for 0.27 nodes/m^2 nodes density, the error was minimized.

In [8], an indoor positioning system based on low power Wi-Fi Tag4M was proposed. Herein, in order to infer the distance, the received signal strength was used. Thus, the distance between the Tag4M and the AP was determined using circles which had the center in the AP's location.

A presentation of the current existing wireless indoor positioning systems is realized in [9]. The paper described the triangulation schema, the fingerprinting and also several properties for evaluation of the indoor positioning systems.

Another proposal of finding the location in indoor environments is illustrated in [10]. Herein, the system was based on the time measurement principle differential time difference of arrival (DTDOA). The performances of the system were followed for a Gbit/s, 60 GHz high-performance wireless LAN which was under development.

Between the techniques which are used for indoor positioning system is the triangulation technique. According to [11] another technique which performs better comparing to the triangulation technique with unstable received signal strength (RSS) is based on Fuzzy Logic. In this solution, first, the distances between object and stations are measured and further the object coordinate is identified using the Fuzzy logic inference.

Section II introduces the most used positioning techniques. Section III provides a short description of the OWLPS platform, while in section IV is presented the mobile position computation algorithms implemented in OWLPS. Section V presents one experiment conducted for localization together with the results obtained in the experiment.

Mathematical Modeling of a Nitric Acid Refluxer of an ^{15}N Isotope Separation Column

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***Abstract*—The ^{15}N isotope separation column is a very complex process and it's performances depends on ensuring constant flow rates and concentrations of the feeding components. Because of economic reasons, most of the residue compounds are being reused and reintroduced into the system through special chemical reactors called refluxers. In this paper we present the mathematical modeling of a refluxing reactor of a ^{15}N isotope separation column. The models are obtained for the above mentioned chemical process, however, the final equations are described in a general sense, and thus they can be used for other independent heterogeneous reactions. The assessment of the results is made via simulation.**

Keywords-isotope separation column; plug flow reactor; modeling ;heterogeneous reactions

I. INTRODUCTION

The stable isotopes of elements like carbon, nitrogen, or oxygen are widely used in scientific research, medicine, hydrology, or various industrial applications. [1]–[3]. The ratio of natural abundances of the stable isotopes of nitrogen, ^{14}N and ^{15}N isotopes is 99.635/0.365. In certain applications, one may need a higher concentration of ^{15}N isotope. One of the most common procedure for separating ^{15}N isotope is based on the isotopic exchange between the nitric oxide and the nitric acid, and it is described by [3], [4]:

$$^{15}NO + H^{14}NO_3 = {}^{14}NO + H^{15}NO_3 \quad (1)$$

The elementary separation factor for a solution of nitric acid with a concentration of 10M in normal conditions is $\alpha = 1.055$ [3], [5], [6].

In the isotope separation by the isotopic exchange between the nitric oxide and the nitric acid there are nine inputs that determinate the isotopic concentration of the product at the end of the separation cascade [3]. They are:

- The feed flow rate of nitric acid.
- The chemical and isotopic concentration of HNO3.
- The flow rate of the air to the oxidation tower.
- The flow rate of the water to the absorption tower.
- The temperature at which the separation process occurs.
- The flow rate of sulfur dioxide.
- The pressure of the sulfur dioxide.
- The flow rate of water.
- The composition of the nitric oxides in the gas phase.

From the above inputs, the temperature is the only input that affects the separation process directly. The two refluxing

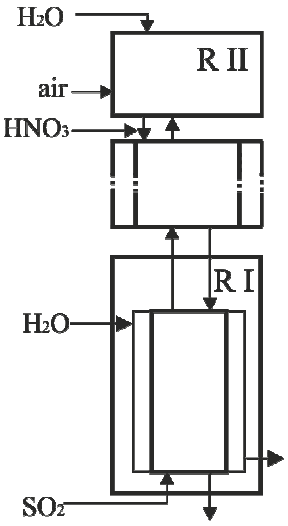

Figure 1. Isotope separation column.

Reactors (Figure 1) are playing a crucial role in ensuring the required conditions for the separation process. In the bottom refluxing reactor (R I), a variation of the flow rate sulfur dioxide will generate a variation of the nitrogen oxides flow rate that will be fed into the isotope separation column. Also, a variation of the cooling water will generate a variation in the temperature of the gases entering the main column, affecting the isotope separation process.

In order to simplify the modeling of the refluxer, we will consider it to be made out of only one reactor.

In this paper we present the mathematical modeling of the bottom refluxing reactor. To the authors' best knowledge we are the first to treat this issue for a ^{15}N isotope separation column.

II. PROCESS DESCRIPTION

In this section we describe the kinetics of the main reactions that takes place in the refluxer.

A. *Flow reactors characteristics*

Analyzing the behavior of the towers forming the top refluxing reactor, we see that each of them is a continuous flow reactor, each tower being continuously fed with reactants and the products of the reactions that take place inside, naturally flow out of the tower being fed to the next reactor in the system.

In order to model the behavior of each tower, we will treat them as plug-flow reactors. The mathematical model is based on three assumptions [7]:

Numerical Analysis of a Wax-paraffin Linear Thermal Actuator with Internal Heat Generation

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***Abstract*—A mathematical model to investigate the steady state temperature distribution in the "active material" of a thermal actuator has been developed according to different actuator response time intervals. The analytical solution presented in this paper is used as a preliminary step in order to develop refreshable Braille devices based on wax paraffin. The operating phase change material is represented by wax paraffin activated from a mini heater. The active material of the investigated actuator was manufactured with a 1mm diameter and a length of 5mm. A preliminary sizing of the mini heater was necessary for melting the paraffin in order to generate actuator stroke due to volume variation (for different imposed time intervals). Moreover, a finite element based simulation using ANSYS 12-Thermal Analysis was performed in order to validate the proposed analytical model.**

Keywords-linear thermal actuator; conduction; internal heat generation; numerical analysis;

I. INTRODUCTION

The development of wax paraffin thermal actuators has received considerable attention in recent years, especially in the fabrication of more reliable micro devices. It is well known that the performance of wax paraffin thermal actuators is determined by their reliability, miniaturization, and non magnetic properties.

Phase change materials such as *n*-paraffin (CH_2 – chain) are one of the actual thermal actuators materials used to replace conventional actuators. Among other phase change materials, wax paraffin is an attractive material used for new unconventional thermal actuators. Recently, the interest in simple thermally actuation structures, it increased because of the volume expansion of the active material. Considerable efforts have been made to fabricate paraffin wax thermal actuators using micro fabrication technology [1-5].

In this category, a wide variety of numerical, experimental and comparative studies have appeared in last years, dealing with a variety of applications in thermal conduction field of thermodynamics. Several studies dealing with these issues are presented. Heat conduction in multilayer structure of complex geometries, the mathematical formulation of the steady-state conduction in multi-dimensional and multilayer bodies, heat conduction through composite slabs having geometrical complexity were presented and discussed in [6-8].

Numerical analysis of one-dimensional, two-dimensional and steady or unsteady heat conduction, simulations techniques using finite elements with non-linear physical properties and boundary conditions, transfer functions methods are presented in [9-19].

Thermal actuators have been extensively explored due to manufacturability and simplicity of actuator based structures. An electro-thermally driven nickel micro-actuator has been modeled and simulated with finite element method [20]. In order to improve de performance of the micro-actuator, the authors proposed in [21] a dynamic thermal modeling using electrical analogy. Simulation and experimental measurements of a force was obtained using a novel dual stage in situ force gauge that performs the functions of both a fixed load spring and a movable force gauge. Nonlinear finite element models are used to simulate the behavior in order to provide predictions of the force output capability [22]. In the same category an analytical method to determine the temperature distribution in thermal micro sensors is presented and classified into different typologies depending on the boundary conditions at their edges [23].

In phase change material category, a micro actuator was successfully developed, demonstrated and operated at either 10 or 15 V, in order to integrate it into micro fluidic valves, micro grippers and micro pipettes [24]. A study aimed to develop an electro thermal actuator, continuing with the modeling and fabrication. The displacement is generated due to the different thermal expansion rate between its two layers [25]. A parametric study of geometric and operation parameters of the liquid-vapor phase change actuator was developed to predict the dynamic behavior. The analyzed model showed that faster response times and higher sensitivity can be achieved if the thermal inertia and heat loss coefficient values are reduced [26].

Wax paraffin, as a thermal actuation material, is proposed in some designated applications due to low-priced, large expansion, chemically inert, strength and ~15% volume expansion properties. The melting of the material can be done easily with thermal heaters at low voltage.

The purpose of this study is to establish a numerical analysis of the thermal behavior during phase change process. In this study a conduction analysis with internal heat generation source was raised.

Modeling and stability analysis of the claw-pole synchronous generator

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ABSTRACT. This paper presents the system based on claw-pole car alternators that uses renewable energy supplies for electricity generation in isolated locations with a water/wind source. The mechanical energy is provided by a hydraulic or wind turbine connected to a car alternator. This equipment is cheap and easy to produce because the spare-parts are easy to find and also it doesn't need a battery or other components because it's self-excited. The claw-pole alternator produces three-phase AC current that passes through a rectifier diode bridge obtaining a DC current. Approximately 15% of the produced DC current will be used as self-exiting current for the alternator via electric circuit.

I. INTRODUCTION

The continuous trend to use renewable and no contaminant energy supplies for electricity generation is in a continuous expansion in many countries. The electricity generator system development is based on the use of wind, water and solar energies, even with a low output power level, and addressed to small users, dispersed in isolated areas.

The paper presents the system based on claw-pole generators ("car alternators", "Lundell generators", etc) as generating components. Given the wide range of electric generators present on the market, this choice is justified by the widespread use of cars and trucks in all regions. Car alternators are very rugged and their spare-parts are widely available in many places where other electric equipment is hard to find. The combination of water/wind turbines for use in isolated location is the solution.

The car alternator (Lundell alternator) is a wound-field three-phase synchronous generator containing an internal three-phase rectifier diode bridge on a circuit for field current control. The rotor consists of a pair of stamped pole pieces (claw-poles), secured around a cylindrical field winding driven via slip rings and carbon brushes, figure 1.

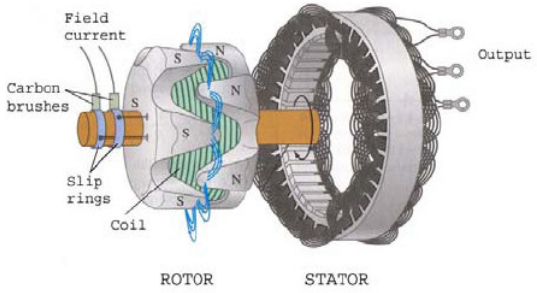

Figure 1. The structure of the car alternator [1]

The rated power of the car alternators is continuously developed, as is represented in figure 2.

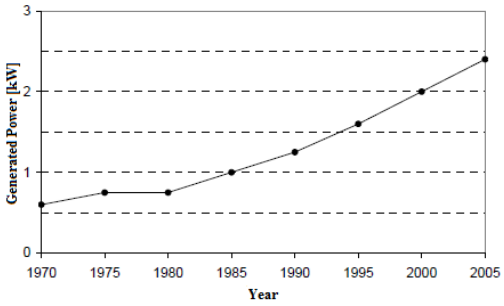

Figure 2. Evolution of the car alternators [1]

A considerable amount of work was invested into developing higher power automotive alternators with improved efficiency. Most of this work was focused on induction, switched reductance, surface or interior permanent magnet machines.

II. MAIN PARAMETERS OF THE CAR ALTERNATOR

The car alternators can operate in a wide range, from 400 rot/min up to 8000 rot/min, being available for more standard voltages: 12, 24, 36 or 48V. The current operating capacity, up to 320A in modern units, is another advantage. The alternator can operate for broad temperature changes without significant performance degradation.

A sensitive part of the car alternators is the brush-system, some models in brushless configuration being today available.

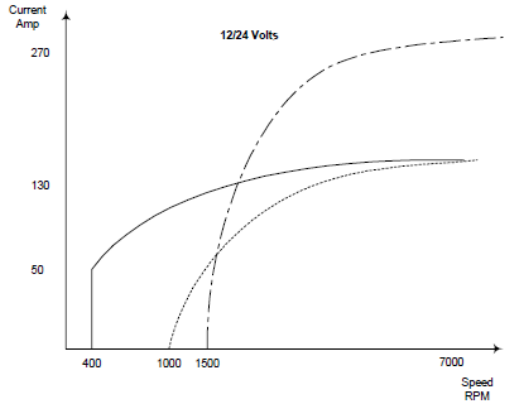

Figure 3. The speed versus the output voltage of the alternator [2]

Artificial Intelligence Based Method for the Assessment of the Training Level of Different Age Groups

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***Abstract*—The paper proposes a fuzzy based method to evaluate the level of physical preparedness of both adult and older adult nonathletes and athletes based on a number of physiological parameters. An objective tool to assess the training level of the athletes would also be most useful for trainers and coaches. It would prevent undesirable events such as under-training or overtraining. In the case of nonathletes, monitoring the physiological parameters and determining the cardiorespiratory fitness level could prevent the modern chronic diseases. Two evaluation algorithms are proposed in this paper. The first one evaluates the training level of adult nonathletes and athletes, and the second one evaluates the training level of older adult nonathletes and athletes. Both algorithms were implemented in Java 2 Standard Edition. They were tested with data collected from human subjects. The obtained results are in accordance with the interpretation of the data given by exercise physiologists.**

Keywords-artificial intelligence, training level, physiological parameter

I. INTRODUCTION

When exposed to repeated bouts of exercise over a period of time, the human body responds by adapting [1]. This phenomenon implies complex physiological changes. The most obvious physiological alterations observed in humans as consequences of training regard the cardiovascular function, the respiratory function, the neuromuscular system, the metabolism and the basic energy systems. Assessing these alterations is not an easy thing to do. It usually requires expensive equipment and controlled conditions [2]. Still, the most challenging task is giving meaningful interpretations to the measured variables. The data yielded from specific laboratory and field tests are useless unless integrated in the right response pattern. There are some limitations regarding the ability of the clinical exercise testing in giving a diagnosis [3]. These limitations regard the biological variability of the individuals and the variability of the data existing in the literature. Maximum heart rate (HR_{max}) would be a good example to illustrate the variability of the same physiological parameter from one individual to another. Maximum heart rate (HR_{max}) is the maximal value of a person's heart rate achieved while exercising near the point of exhaustion. Maximum heart rate can be calculated with (1).

$$HRmax = 220 - age\ in\ years \quad (1)$$

For a 40 year old, the maximum heart rate would be 180 beats/min (HR_{max} = 220 - 40). However, this is only an average value and it has to be treated accordingly. In real life, 68% of all 40 year old have maximum heart rate values between 168 and 192 beats/min (mean ± 1 standard deviation), and 95% have maximum heart rate values between 156 and 204 beats/min (mean ± 2 standard deviation) [1]. Regarding the variability of the available data in the literature, stroke volume (SV) is an appropriate example. The stroke volume (SV) of the heart is the amount of blood pumped per contraction. There are two situations to take into consideration when talking about stroke volume: at rest, and during maximal exercise. While at rest, an untrained individual would have a stroke volume value somewhere in between 50 to 60 ml. During maximal exercise, the same individual would have a stroke volume value in between 100 to 120 ml. These are the values given by Wilmore and Costill in their book [1]. A few chapters later, the same authors present a table that lists the following stroke volume values for an untrained individual: 55-75 ml at rest, and 80-110 ml during maximal exercise [1]. This is rather confusing. Another confusing situation is that two scientific papers give different values for the same physiological parameter. For example, Wells and Norris [4] give a value of 25-40 $ml*kg^{-1}*min^{-1}$ for the maximal oxygen uptake ($VO2_{max}$) of an average healthy sedentary adult. Wilmore and Costill [1] give values for males, females and different age groups: nonathlete males, 40-49 years, have $VO2_{max}$ values between 36-44 $ml*kg^{-1}*min^{-1}$, and nonathlete females of the same age have $VO2_{max}$ values between 26-35 $ml*kg^{-1}*min^{-1}$.

These are the reasons why only experienced, highly trained professionals (clinicians and exercise physiologists) are able to interpret the results of laboratory and field tests designed for measuring the physiologic parameters, which define the effort capacity of humans. The whole process of measuring the parameters and interpreting them accordingly is a time and resources consuming process. It is also a rather subjective process since the results of the tests need to be classified by humans. Consequently, this paper proposes a fuzzy method to evaluate the level of physical preparedness of both adult and older adult nonathletes and athletes based on a number of physiological parameters. The immediate benefit for athletes would be the fact that coaches and trainers would not need the help of exercise physiologists to know their level of training. There are other implications, too.